Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan

November 30, 2009

Prepared by
National Marine Fisheries Service
Northwest Region

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With respect to the Middle Columbia Steelhead Recovery Plan, where areas of disagreement arose between a management unit plan and the species level, distinct population segment (DPS) plan, NMFS worked with the relevant parties to resolve the differences and in a few cases, identified in the DPS plan, decided not to incorporate the disputed material into the DPS plan.

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Acknowledgements

The Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan represents the dedicated effort of numerous individuals, organizations, recovery boards, and interested citizens over many years in the Mid-Columbia River basin. In particular, we would like to thank NMFS consultant Margaret Hollenbach, who served as recovery plan writer and editor throughout the multi-year process of producing this plan. We would also like to thank the Middle Columbia Recovery Forum Steering Committee members, Management Unit organization members, and Middle Columbia Recovery Forum meeting participants for their input, support, and guidance throughout this recovery planning process. These individuals also provided valuable comments on draft versions of the recovery plan. In addition, the Interior Columbia Technical Recovery Team was instrumental in providing a comprehensive science basis for the plan, as well as reviewing and commenting on earlier drafts. NMFS reviewers of the plan were: Elizabeth Holmes Gaar, Rob Walton, Laurie Beale, Susan Pultz and Larissa Plants.

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Contents

Acronyms and Abbreviations ..... **ix**

Recovery Planning Glossary ..... **xi**

Executive Summary ..... **ES-i**

1. Introduction **1-1**

1.1 ESA Requirements 1-3
1.2 How NMFS Intends to Use the Plan 1-4
1.3 Middle Columbia Steelhead DPS Geographic Setting 1-5
1.4 Relationship of Steelhead DPS to Resident *O. mykiss* 1-5
1.5 Context of Plan Development 1-6
1.5.1 Recovery Domains and Technical Recovery Teams 1-7
1.5.2 Management Units 1-8
1.6 Management Unit Recovery Plans and Modules 1-9
1.6.1 Oregon Steelhead Recovery Plan 1-11
1.6.2 Washington Gorge Management Unit Recovery Plan 1-11
1.6.3 Southeast Washington Plan 1-12
1.6.4 Yakima Steelhead Recovery Plan 1-13
1.7 Recovery Planning Modules 1-13
1.7.1 Hydro Module 1-13
1.7.2 Estuary Module 1-14
1.8 Tribal Trust and Treaty Responsibilities 1-14

2. Biological Background **2-1**

2.1 Steelhead Distribution, Life History, and Habitat 2-1
2.2 DPS Biological Structure 2-3
2.2.1 Distinct Population Segments 2-3
2.2.2 Major Population Groups 2-4
2.2.3 Independent Populations 2-4
2.3 Middle Columbia River Steelhead MPGs and Populations 2-5
2.3.1 Cascades Eastern Slope Tributaries MPG 2-6
2.3.2 John Day River MPG 2-6
2.3.3 Umatilla/Walla Walla MPG 2-7
2.3.4 Yakima River MPG 2-8
2.4 Viable Salmonid Populations 2-9
2.4.1 Abundance and Productivity 2-9
2.4.2 Spatial Structure and Diversity 2-10
2.5 Critical Habitat 2-10

3. Recovery Goals and Delisting Criteria **3-1**

3.1 Biological Viability Criteria 3-1

3.1.1 DPS Viability Criterion 3-2
3.1.2 Major Population Group Viability Criteria 3-2
3.1.3 Population-Level Viability Criteria 3-3
3.1.4 Recovery Scenarios 3-5
3.2 Recovery Goals and Criteria Adopted by Management Unit Plans 3-11
3.2.1 Oregon Steelhead Recovery Plan 3-11
3.2.1.1 Broad Sense Recovery Goal 3-11
3.2.1.2 Recovery Objectives 3-11
3.2.1.3 Viability Criteria 3-12
3.2.1.4 Recovery Scenario 3-12
3.2.2 Washington Gorge Management Unit Plans 3-13
3.2.2.1 Broad Sense Recovery Goal 3-13
3.2.2.2 Recovery Objectives 3-14
3.2.2.3 Viability Criteria 3-14
3.2.2.4 Recovery Scenario 3-14
3.2.3 Southeast Washington Plan 3-14
3.2.3.1 Broad Sense Goal 3-15
3.2.3.2 Recovery Objectives – Planning Targets 3-15
3.2.3.3 Viability Criteria 3-15
3.2.3.4 Recovery Scenario 3-15
3.2.4 Yakima Steelhead Recovery Plan 3-16
3.2.4.1 Broad Sense Recovery Goal 3-16
3.2.4.2 Recovery Objectives/Scenarios 3-16
3.2.4.3 Viability Criteria 3-17
3.3 Listing Factors/Threats Criteria 3-18
3.4 Delisting Decision 3-22

4. Current Status Assessment of DPS 4-1
4.1 ICTRT Status Assessment of Middle Columbia Steelhead DPS 4-1
4.2 Viability Curves 4-1
4.3 Spatial Structure and Diversity 4-4
4.4 Population-Level Risk Rating 4-7
4.5 Current Population Status 4-9
4.6 MPG Status 4-9
4.7 DPS Status 4-9

5. The 'Gap' Between Current and Desired Status 5-1
5.1 Gaps Using Abundance and Productivity Criteria 5-1
5.2 Gaps using Spatial Structure and Diversity Criteria 5-3

6. Limiting Factors and Threats 6-1
6.1 Types of Limiting Factors 6-2
6.2 Types of Threats 6-3
6.3 Limiting Factors and Threats for the Middle Columbia Steelhead DPS 6-4
6.3.1 Tributary Habitat Conditions 6-4
6.3.2 Columbia River Mainstem Conditions 6-5

6.3.2.1 Impaired Fish Passage....6-5
6.3.2.2 Water Temperature and Thermal Refuges....6-9
6.3.2.3 Changes in Mainstem Columbia Nearshore Habitat....6-9
6.3.3 Impaired Fish Passage in Tributaries....6-9
6.3.4 Hatchery-Related Adverse Effects....6-10
6.3.5 Predation/Competition/Disease....6-12
6.3.5.1 Pinnipeds....6-12
6.3.5.2 Birds....6-12
6.3.5.3 Piscivorous Fish....6-13
6.3.5.4 Competition....6-14
6.3.5.5 Disease....6-15
6.3.6 Degradation of Estuarine and Nearshore Marine Habitat....6-15
6.3.7 Harvest....6-15
6.3.7.1 Ocean Fisheries....6-16
6.3.7.2 Mainstem Columbia Fisheries....6-16
6.3.8 Climate Change....6-18
6.4 MPG Limiting Factors....6-19
6.4.1 Cascades Eastern Slope Tributaries MPG....6-19
6.4.2 John Day River MPG....6-20
6.4.3 Umatilla/Walla Walla MPG....6-21
6.4.4 Yakima River MPG....6-22

7. Recovery Strategy....7-1
7.1 DPS Level Recovery Strategy....7-2
7.1.1 NMFS 2006 Listing Decision Recommendations....7-2
7.1.2 Tributary and Columbia Mainstem Habitat....7-4
7.1.3 Impaired Fish Passage....7-4
7.1.3.1 Impaired Fish Passage in Mainstem Columbia River....7-5
7.1.3.2 Impaired Fish Passage in Tributaries....7-7
7.1.4 Hatchery Reforms....7-7
7.1.5 Predation, Competition and Disease....7-9
7.1.5.1 Predation....7-9
7.1.5.2 Competition – Density Dependent Mortality....7-11
7.1.5.3 Disease....7-11
7.1.6 Harvest....7-12
7.1.7 Estuary and Columbia River Plume....7-12
7.1.8 Climate Change....7-13
7.1.9 Coordination/Governance....7-15
7.1.10 Research, Monitoring and Evaluation and Adaptive Management....7-16
7.2 Summary of Recovery Strategies for the MPGs....7-16
7.2.1 Cascades Eastern Slope Tributaries MPG....7-17
7.2.2 John Day River MPG....7-23
7.2.3 Umatilla/Walla Walla MPG....7-27
7.2.4 Yakima River MPG....7-32
7.3 Setting Priorities....7-36

7.3.1 Oregon Steelhead Recovery Plan 7-36
7.3.2 Washington Gorge Management Unit Plans 7-40
7.3.2.1 Klickitat Recovery Plan 7-40
7.3.2.2 Rock Creek Recovery Plan 7-40
7.3.2.3 White Salmon Recovery Plan 7-41
7.3.3 Southeast Washington Plan 7-41
7.3.4 Yakima Steelhead Recovery Plan 7-42

8. Site-Specific Management Actions and Cost Estimates 8-1
8.1 Site-Specific Management Actions 8-1
8.2 Cost Estimates 8-2
8.2.1 Oregon Middle Columbia Steelhead Recovery Plan 8-4
8.2.2 Washington Gorge Management Unit Plan 8-4
8.2.2.1 Klickitat Recovery Plan 8-5
8.2.2.2 Rock Creek Recovery Plan 8-5
8.2.2.3 White Salmon Steelhead Recovery Plan 8-5
8.2.3 Southeast Washington Plan 8-5
8.2.4 Yakima Steelhead Recovery Plan 8-5
8.3 Time Estimate 8-5

9. Potential Effects of Proposed Recovery Actions 9-1
9.1 Integration Approach 9-2
9.1.1 EDT Model 9-3
9.1.2 AHA Model 9-4
9.2 Effects of Recovery Actions 9-5
9.2.1 Cascades Eastern Slope Tributaries MPG 9-5
9.2.2 John Day River MPG 9-11
9.2.3 Umatilla/Walla Walla MPG 9-16
9.2.4 Yakima MPG 9-20
9.3 Aggregate Analysis 9-24
9.3.1 Cascades Eastern Slope MPG 9-24
9.3.2 John Day River MPG 9-25
9.3.3 Umatilla/Walla Walla MPG 9-26
9.3.4 Yakima MPG 9-26
9.4 Summary of Expected Benefits of Proposed Actions for Mid-Columbia Steelhead DPS 9-27

10. Research, Monitoring and Evaluation for Adaptive Management 10-1
10.1 Designing a Monitoring and Evaluation Program to Support Adaptive Management 10-2
10.2 ESU/DPS Status Assessment and Adaptive Management 10-5
10.3 Research on Key Uncertainties 10-6
10.3.1 Ocean Productivity and Natural Variation 10-6
10.3.2 Global Climate Change 10-6
10.3.3 Hatchery Effectiveness 10-7
10.3.4 Differential Delayed Mortality of Transported Steelhead (D Value) 10-7

10.3.5 Invasive Species 10-7
10.3.6 Independent Populations 10-7
10.3.7 Effects of Interacting Strategies/Actions 10-8
10.3.8 Effects of Human Population Growth 10-8
10.3.9 Resident-Anadromous *O. mykiss* Interactions 10-8
10.4 Important Data Gaps 10-9
10.4.1 Abundance and Productivity 10-9
10.4.2 Spatial Structure and Diversity 10-10
11. Implementation and Coordination 11-1
11.1 Implementation Roles and Responsibilities 11-2
11.1.1 Mid-C Forum 11-3
11.1.2 Management Unit Leads 11-5
11.1.3 Washington Regional Recovery Boards 11-7
11.1.4 Oregon Implementation Coordinator and Advisory Board 11-7
11.1.5 NMFS 11-8
11.1.5.1 ESA Responsibilities 11-8
11.1.5.2 Mid-C Convening Partner 11-9
11.1.6 Technical Teams 11-9
11.1.7 Science Team 11-9
11.2 Funding and Resources 11-10
11.2.1 Implementation Funding ..... 11-**Error! Bookmark not defined.**
11.2.2 Funding for Mid-C Forum Activities 11-10
12 Bibliography 12-1

Appendices

Appendix A Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment http://www.eou.edu/~odfw/Oregon_Mid-C_Recovery_Plan_FRN_August_2009_.pdf

Appendix B Recovery Plan for the Klickitat River Population of the Middle Columbia River Steelhead DPS - www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Mid-Columbia/Mid-Col-Plan.cfm)

Appendix C Recovery Plan for the Rock Creek Population of the Middle Columbia River Steelhead DPS - http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Mid-Columbia/Mid-Col-Plan.cfm

Appendix D Snake River Salmon Recovery Plan for Southeast Washington (Southeast Washington Plan) http://www.snakeriverboard.org/resources/library.htm

Appendix E Yakima Steelhead Recovery Plan http://www.ybfwrb.org/RecoveryPlan/8-18-08%20Yakima%20Steelhead%20Recovery%20Plan.pdf

Appendix F Columbia River Hydro Modulehttp://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Hydro-Module.pdf

Appendix G Columbia River Estuary Module http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm

Appendix H Recovery Plan for the White Salmon Population of the Middle Columbia River Steelhead DPS: In preparation

Figures

Figure ES-1 Geographic Boundaries of the Middle Columbia River Steelhead DPS, showing land ownership. ..... ES-ii

Figure ES-2 Columbia Basin Recovery Domains for NMFS Northwest Region ..... ES-vi

Figure ES-3 Management Units and Populations for the Middle Columbia River Steelhead DPS..... ES-ix

Figure ES-4 Middle Columbia River Steelhead Populations and Major Population Groups. ..... ES-xii

Figure ES-5 Viability Ratings for Middle Columbia Steelhead Populations by MPG. ..... ES-xix

Figure ES-6 Predicted viability results for Mid-Columbia Steelhead Populations after 25 years of major restoration efforts. ..... ES-xxxix

Figure ES-7 Mid-C Recovery Plan Implementation Organizational Structure. ..... ES-xli

Figure 1-1 Geographic boundaries of the Middle Columbia River Steelhead DPS. 1-2

Figure 1-2 Columbia Basin Recovery Domains for NMFS Northwest Region. 1-8

Figure 1-3 Management Units and Populations for the Middle Columbia River Steelhead DPS. 1-10

Figure 2-1 Hierarchical levels of salmonid species structure as defined by the TRTs for ESU/DPS recovery planning. 2-4

Figure 2-2 Middle Columbia River Steelhead Populations and Major Population Groups. 2-7

Figure 2-3 Middle Columbia Steelhead DPS Structure. 2-5

Figure 2-4 Middle Columbia Steelhead Critical Habitat. 2-12
Figure 3-1 Major Population Group Viability Criteria. 3-3
Figure 3-2 Recovery Scenarios: Application of ICTRT MPG Viability Criteria to Middle Columbia River Steelhead MPGs: Options for Viability 3-7
Figure 4-1 Middle Columbia River Steelhead Basic Populations.....4-3
Figure 4-2 Middle Columbia River Steelhead Intermediate Populations 4-3
Figure 4-3 Middle Columbia River Steelhead Large Populations. 4-4
Figure 4-4 Middle Columbia River Steelhead Very Large Populations. 4-4
Figure 4-5 Assessing Population Viability Across VSP Criteria. 4-8
Figure 4-6 Middle Columbia Steelhead Population Viability. 4-9
Figure 4-7 Viability Ratings for Middle Columbia Steelhead Populations by MPG. 4-10
Figure 5-1 Survival and Mortality throughout Salmonid Life Cycle. 5-2
Figure 6-1 Major Dams and Barriers to Migration for Middle Columbia Steelhead. 6-6
Figure 9-1 Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves for the different size Steelhead Populations within the Cascades Eastern Slope MPG. 9-30
Figure 9-2 Relationship of Projected Abundance/Productivity estimates to 5% Risk Curves for the different size Steelhead Populations within the John Day MPG. 9-31
Figure 9-3 Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves for the different size Steelhead populations within the Umatilla/Walla Walla MPG....9-32
Figure 9-4 Relationship of Projected Abundance/Productivity estimates to 5% risk curves for the different size Steelhead Populations within the Yakima MPG. 9-33
Figure 9-5 Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves for the different size Steelhead Populations within the Mid-Columbia DPS. 9-34
Figure 10-1 NMFS Listing Status Decision Framework 10-4
Figure 11-1 Mid-C Recovery Plan Implementation Organizational Structure 11-2

Tables

Table ES-1 Middle Columbia Steelhead size Categories.... ES-xv
Table ES-2 Mid-Columbia Steelhead DPS Populations: Summary Of Abundance, Productivity, Risk Ratings, and Minimum Abundance Thresholds....ES-xviii
Table ES-3 Median Survival Gap For The Major Population Groups of the Middle Columbia Steelhead DPS. .... ES-xx
Table ES-4 Summary of Cost Estimates for Habitat Projects for Middle Columbia DPS.....ES-xxxviii
Table 2-1 Key habitat requirements by life stage and time period for steelhead. 2-2
Table 2-4 Types of sites and essential physical and biological features designated as PCEs for steelhead, and the life stage each PCE supports. 2-13
Table 3-1 Abundance and Productivity Thresholds. 3-4

Table 3-2 Oregon Mid-C steelhead population characteristics and minimum abundance and productivity needed. 3-12

Table 3-3 Yakima Steelhead Populations Abundance and Productivity Criteria.....3-17

Table 4-1 Middle Columbia River steelhead DPS populations: summary of abundance, productivity, risk ratings, and minimum abundance thresholds.....4-2

Table 5-1 Minimum changes in survival of Middle Columbia River steelhead needed to meet abundance and productivity criteria.....5-4

Table 6-1 Key limiting factors and common characteristics used to describe them. 6-3

Table 6-2 Mid-Columbia River Steelhead DPS Juvenile Survival (migrating downstream).....6-7

Table 6-3 Mid-Columbia River Steelhead DPS Adult Survival (migrating upstream).....6-8

Table 7-1 Recovery Strategies and Actions for the Cascades Eastern Slope Tributaries MPG.....7-20

Table 7-2 Recovery Strategies and Actions for the John Day River MPG. 7-25

Table 7-3 Recovery Strategies and Actions for the Umatilla/Walla Walla MPG. 7-29

Table 7-4 Recovery Strategies and Actions for the Yakima Basin MPG. 7-34

Table 7-5 Integrated approach to address threats and factors limiting recovery of Oregon's Mid-Columbia River steelhead populations. 7-37

Table 8-1 Summary of Cost Estimates for Habitat Projects for Mid-Columbia Steelhead DPS. 8-3

Table 9-1 Estimated Productivity and Abundance of Deschutes River Westside Steelhead with Proposed Actions. 9-6

Table 9-2 Estimated Productivity and Abundance of Deschutes River Eastside Steelhead with Proposed Actions. 9-7

Table 9-3 Estimated Productivity and Abundance of Klickitat River steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.....9-8

Table 9-4 Estimated Productivity and Abundance of Fifteenmile Creek Steelhead associated with Combinations of all Priority Tributary and Out-of Subbasin Actions. 9-9

Table 9-5 Estimated Proportional Changes in Average Base-Period Productivity of Rock Creek Steelhead.....9-11

Table 9-6 Estimated Productivity and abundance of Lower John Day River steelhead. 9-12

Table 9-7 Estimated Productivity and Abundance of North Fork John Day River Steelhead. 9-13

Table 9-8 Estimated Productivity and Abundance of Middle Fork John Day River Steelhead. 9-14

Table 9-9 Estimated Productivity and Abundance of South Fork John Day River Steelhead. 9-15

Table 9-10 Estimated Productivity and Abundance of Upper John Day River Steelhead. 9-16

Table 9-11 Estimated Productivity and Abundance of Umatilla River Steelhead. 9-17

Table 9-12a Estimated Productivity and Abundance of Walla Walla River Steelhead – Oregon and Washington Actions.....9-18

Table 9-12b Estimated Productivity and Abundance of Walla Walla River Steelhead – Oregon Actions. 9-18

Table 9-13 Estimated Productivity and Abundance of Touchet River Steelhead. 9-20

Table 9-14 Estimated Productivity and Abundance of Satus Creek Steelhead (tributary only). 9-21

Table 9-15 Estimated Population Performance (Productivity and Abundance) of Toppenish River Steelhead. 9-22

Table 9-16 Estimated Productivity and Abundance of Naches River Steelhead. 9-23

Table 9-17 Estimated Productivity and Abundance of Upper Yakima River Steelhead.....9-24

Table 9-18 Total changes in Productivity of Mid-Columbia River Steelhead expected from Current and Prospective Recovery Actions. 9-27

Table 9-19 Total changes in Abundance of Mid-Columbia River steelhead expected from Current and Prospective Recovery Actions. 9-29

ACRONYMS AND ABBREVIATIONS

A/P	abundance and productivity
AHA	All-H-Analyzer
BiOp	Biological Opinion
BOR	US Bureau of Reclamation
BPA	Bonneville Power Administration
BRT	Biological Review Team
CA	Comprehensive Analysis of Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions
CBFWA	Columbia Basin Fish & Wildlife Authority
COE	US Army Corps of Engineers
CWT	coded-wire-tagging
DPS	distinct population segment
EDT	Ecosystem Diagnosis and Treatment
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FMEP	Fisheries Management and Evaluation Plan
FR	Federal Register
GIS	Geographic Information System
GNRO	Governor's Natural Resources Office (Oregon)
GSRO	Governor's Salmon Recovery Office (Washington State)
HCP	Habitat Conservation Plan
HGMP	Hatchery and Genetic Management Plan
ICBTRT	Interior Columbia Basin Technical Recovery Team
ICTRT	Interior Columbia Technical Recovery Team
LWD	large woody debris
MCSB	Middle Columbia Sounding Board (Oregon)
MPG	major population group
MSA	major spawning areas
N/A	Not Applicable
NGO	non-governmental organizations

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC or NWPCC	Northwest Power and Conservation Council
ODFW	Oregon Department of Fish and Wildlife
OPSW	Oregon Plan for Salmon and Watersheds
PRBC	Pelton-Round Butte Complex
RBH	Round Butte Hatchery
RIST	Recovery Implementation Science Team
RM	river mile
SCA	Supplemental Comprehensive Analysis
SRSRB	Snake River Salmon Recovery Board
SS/D	spatial structure and diversity
TBD	To Be Determined
TRT	Technical Recovery Team
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area
YBFWRB	Yakima Basin Fish and Wildlife Recovery Board
YN	Yakama Nation
YSPB	Yakima Subbasin Fish and Wildlife Planning Board

Recovery Planning Glossary

abundance: In the context of salmon recovery, unless otherwise qualified, abundance refers to the number of adult fish returning to spawn, measured over a time series.

adaptive management: Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.

anadromous fish: Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.

baseline monitoring: In the context of recovery planning, baseline monitoring is done before implementation, in order to establish historical and/or current conditions against which progress (or lack of progress) can be measured.

biogeographical region: an area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms (in this case, salmonids) have evolved in common.

broad sense recovery goals: Goals defined in the recovery planning process, generally by local recovery planning groups, that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values.

compliance monitoring: Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.

delisting criteria: Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a NMFS determination and may include both technical and policy considerations.

distinct population segment (DPS): A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NMFS policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.

diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size,

developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.

endangered species: A species in danger of extinction throughout all or a significant portion of its range.

effectiveness monitoring: Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?

ESA recovery plan: A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.

evolutionarily significant unit (ESU): A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species.

extinct: No longer in existence. No individuals of this species can be found.

extirpated: Locally extinct. Other populations of this species exist elsewhere. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

factors for decline: Five general categories of causes for decline of a species, listed in the Endangered Species Act section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or human-made factors affecting its continued existence.

functionally extirpated: Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population.

hyporheic zone: Area of saturated gravel and other sediment beneath and beside streams and rivers where groundwater and surface water mix.

implementation monitoring: Monitoring to determine whether an activity was performed and/or completed as planned.

independent population: Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.

indicator: A variable used to forecast the value or change in the value of another variable.

interim regional recovery plan: A recovery plan that is intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.

intrinsic potential: The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

intrinsic productivity: The expected ratio of natural-origin offspring to parent spawners at levels of abundance below carrying capacity.

kelts: Steelhead that are returning to the ocean after spawning and have the potential to spawn again in subsequent years (unlike most salmon, steelhead do not necessarily die shortly after spawning).

large woody debris (LWD): A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.

legacy effects: Impacts from past activities that continue to affect a stream or watershed in the present day.

limiting factor: Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status.

locally developed recovery plan: A plan developed by state, tribal, regional, or local planning entities to address recovery of a species. These plans are being developed by a number of entities throughout the region to address ESA as well as state, tribal, and local mandates and recovery needs.

maintained status: Population status in which the population does not meet the criteria for a viable population but does support ecological functions and preserve options for ESU/DPS recovery.

major population group (MPG): A group of salmonid populations that are geographically and genetically cohesive. The MPG is a level of organization between demographically independent populations and the ESU or DPS.

major spawning area (MaSA) A system of one or more branches that contain sufficient spawning and rearing habitat to support more than 500 spawners. For Interior Columbia salmonid populations, defined using results from intrinsic potential analysis.

management unit: A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.

metrics: A metric is something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.

minor spawning area (MiSA) A system of one or more branches that contains sufficient spawning and rearing habitat to support 50 – 500 spawners (defined using intrinsic potential analysis).

morphology: The form and structure of an organism, with special emphasis on external features.

natural-origin fish: Fish that were spawned and reared in the wild, regardless of parental origin.

parr: The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.

phenotype: Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties, or behavior.

piscivorous: (Adj.) Describes fish that eat other fish.

productivity: The average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

recovery domain: An administrative unit for recovery planning defined by NMFS based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.

recovery goals: Goals incorporated into a locally developed recovery plan, which may include delisting (i.e. no longer considered endangered or threatened), reclassification (e.g., from endangered to threatened), and/or other goals. Broad sense goals are a subset of recovery goals (see glossary entry above).

recovery plan supplement: A NMFS supplement to a locally developed recovery plan that describes how the plan addresses ESA requirements for recovery plans. The supplement also

proposes ESA delisting criteria for the ESUs addressed by the plan, since a determination of these criteria is a NMFS decision.

recovery scenarios: Scenarios that describe a target status for each population within an ESU, generally consistent with TRT recommendations for ESU viability.

redd: A nest constructed by female salmonids in streambed gravels where eggs are fertilized and deposited.

recovery strategy: Statements that identify the assumptions and logic – the rationale – for the species' recovery program.

riparian area: Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland.

salmonid: Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.

smolt: A juvenile salmonid that is undergoing physiological and behavioral changes to adapt from freshwater to saltwater as it migrates toward the ocean.

spatial structure: Characteristics of a fish population's geographic distribution. Current spatial structure depends upon the presence of fish, not merely the potential for fish to occupy an area.

stakeholders: Agencies, groups, or private citizens with an interest in recovery planning, or those who will be affected by recovery planning and actions.

Technical Recovery Team (TRT): Teams convened by NMFS to develop technical products related to recovery planning. Planning forums unique to specific states, tribes, or regions may use TRT and other technical products to identify recovery actions.

threatened species: A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

threats: Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

viability criteria: Criteria defined by NMFS-appointed Technical Recovery Teams to describe a viable salmonid population, based on the biological parameters of abundance, productivity, spatial structure, and diversity. These criteria are used as technical input into the recovery planning process and provide a technical foundation for development of biological delisting criteria.

viability curve: A curve describing combinations of abundance and productivity that yield a particular risk of extinction at a given level of variation over a specified time frame.

viable salmonid population (VSP): an independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame.

VSP parameters: Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, *Viable salmonid populations and the recovery of evolutionarily significant units* (McElhany et al. 2000).

EXECUTIVE SUMMARY

Introduction

This is a recovery plan (Plan) for the protection and restoration of Middle Columbia River steelhead (*Oncorhynchus mykiss*), which spawn and rear in tributaries to the Columbia River in central and eastern Washington and Oregon (Figure ES-1). The Middle Columbia River steelhead distinct population segment (DPS) was listed as threatened under the Endangered Species Act of 1973 (ESA) on January 5, 2006 (71 FR 834).

Section 4(f) of the ESA requires NOAA's National Marine Fisheries Service (NMFS) to develop recovery plans for marine species listed under the Act. Recovery plans identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA. Although recovery plans are guidance, not regulatory documents, the ESA clearly envisions recovery plans as the central organizing tool for guiding each species' recovery process. Recovery planning is an opportunity to search for common ground among affected parties, to organize protection and restoration of salmonid habitat, and to secure the economic and cultural benefits that accrue to human communities from healthy watersheds and rivers. While Federal, state, and tribal entities can make major contributions to the recovery of Middle Columbia steelhead, the actions of individuals on their land, as well as city and county codes and ordinances promoting conservation, are also essential.

Nineteen of the 33 salmon and steelhead species in the Northwest region are listed as threatened or endangered. The Middle Columbia steelhead is among those with the best prospects of recovery, although it will require considerable political will and investment of long-term effort and funding. Modeling of the potential effects of the actions that are proposed in this plan (see Chapter 9) predicts that the DPS can achieve a low risk of extinction within a reasonable time frame – e.g. 25 to 50 years – if the actions are taken and if they have the predicted effects on steelhead habitat and survival. Cautious though this statement may be, it is a beacon of hope in the complex realm of salmon and steelhead recovery in the Northwest. The following sections tell the story.

ESA Requirements

ESA section 4(a)(1) lists factors for re-classification or delisting that are to be addressed in recovery plans:

A. The present or threatened destruction, modification, or curtailment of [the species'] habitat or range
B. Over-utilization for commercial, recreational, scientific or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting its continued existence

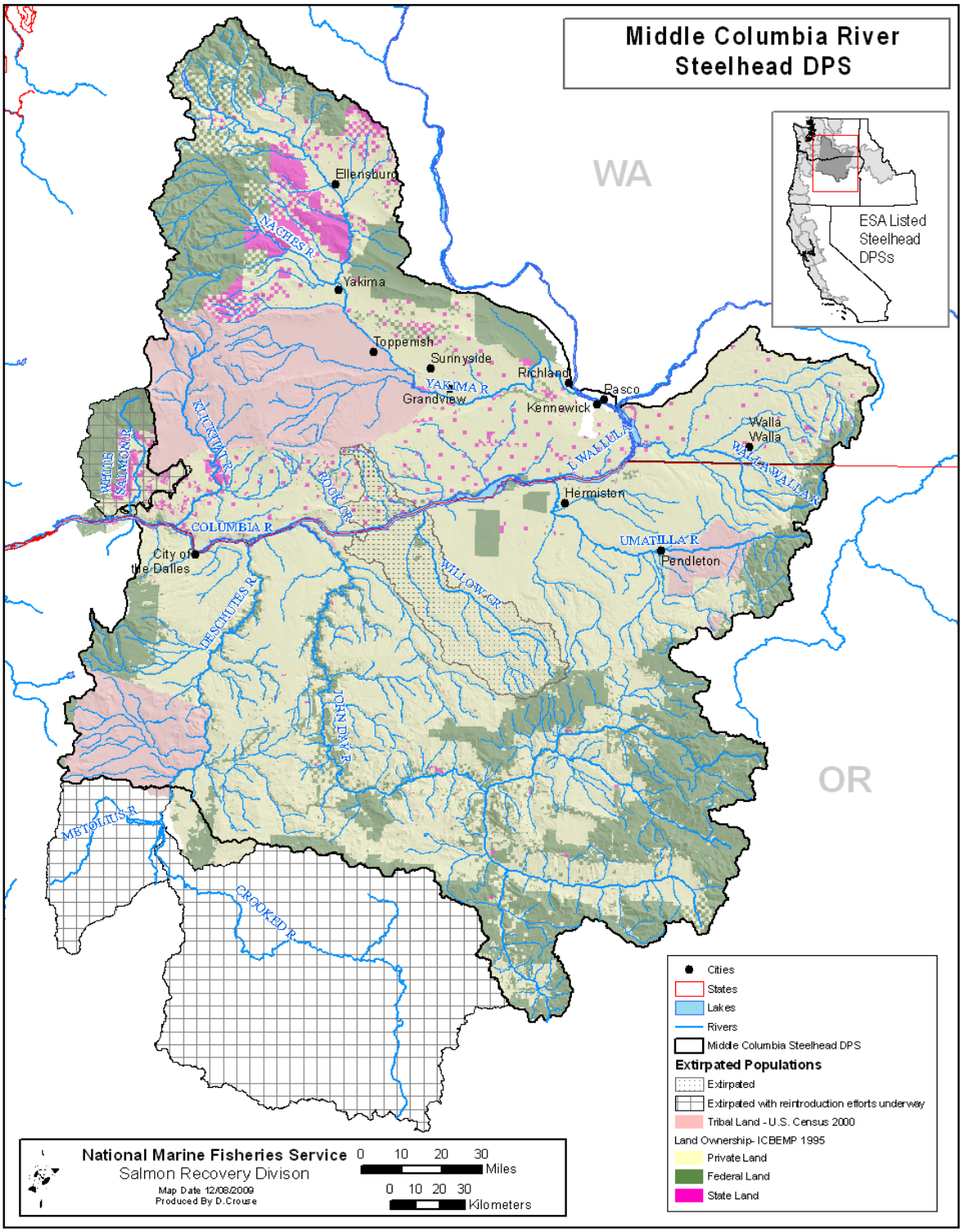


Figure ES-1. Geographic Boundaries of the Middle Columbia River Steelhead DPS, showing land ownership.

ESA section 4(f)(1)(B) directs that recovery plans, to the extent practicable, incorporate:

1. a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
2. objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this chapter, that the species be removed from the list, and;
3. estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In addition, it is important for recovery plans to provide the public and decision makers with a clear understanding of the goals and strategies needed to recover a listed species and the science underlying these conclusions (NMFS 2006).

Once a species is deemed recovered and therefore removed from listed status, section 4(g) of the ESA requires the monitoring of the species for a period of not less than 5 years to ensure that it retains its recovered status.

Steelhead Distribution and Life History

The spawning range of the Middle Columbia River steelhead DPS extends over an area of approximately 35,000 square miles in the Columbia plateau of eastern Washington and eastern Oregon. The DPS includes all naturally spawned populations of steelhead in drainages upstream of the Wind River, Washington, and the Hood River, Oregon (exclusive), up to, and including, the Yakima River, Washington, excluding steelhead from the Snake River Basin (64 FR 14517; 71 FR 849). Major drainages in this DPS are the Deschutes, John Day, Umatilla, Walla Walla, Yakima, and Klickitat river systems. The Cascade Mountains form the western border of the plateau in both Oregon and Washington, while the Blue Mountains form the eastern edge. The southern border is marked by the divides that separate the upper Deschutes and John Day basins from the Oregon High Desert and drainages to the south. The Wenatchee Mountains and Palouse areas of eastern Washington border the Middle Columbia on the north.

Most of the region is privately owned (64 percent), with the remaining area under Federal (23 percent), tribal (10 percent) and state (3 percent) ownership (Figure ES-1). Most of the landscape consists of rangeland and timberland, with significant concentrations of dryland agriculture in parts of the range. Irrigated agriculture and urban development are generally concentrated in valley bottoms. Human populations in these regions are growing.

Steelhead produced in four artificial propagation programs are considered part of the DPS: the Touchet River Endemic Summer Steelhead Program, the Yakima River Kelt Reconditioning Program, and the Umatilla River and Deschutes River steelhead hatchery programs.

The species *Oncorhynchus mykiss* exhibits perhaps the most complex suite of life history traits of any species of Pacific salmonid. These fish can be anadromous (migratory) or freshwater residents (and under some circumstances, apparently yield offspring of the opposite form). Steelhead can spawn more than once (iteroparous), whereas all other *Oncorhynchus* except cutthroat trout (*O. clarki*) spawn once and then die (semelparous).

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. The "runs" are usually named for the season in which the peak occurs. Most steelhead can be categorized as one of two run types, based on their sexual maturity when they re-enter freshwater and how far they go to spawn. In the Pacific Northwest, summer steelhead enter freshwater between May and October and require several months to mature before spawning; winter steelhead enter freshwater between November and April with well-developed gonads and spawn shortly thereafter. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966; Roelofs 1983; Behnke 1992).

The Middle Columbia River steelhead DPS includes populations of inland winter steelhead in the Klickitat River, White Salmon River, Fifteenmile Creek, and possibly Rock Creek.

Relationship of Steelhead DPS to Resident *O. mykiss*

"Steelhead" is the name commonly applied to the anadromous (migratory) form of the biological species *Oncorhynchus mykiss*. The common names of the non-anadromous, or resident, form are rainbow trout and redband trout. When NMFS originally listed the Middle Columbia River steelhead as threatened on March 25, 1999 (64 FR 14517), it was classified as an "evolutionarily significant unit" (ESU) of salmonids that included both the anadromous and resident forms. Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS). NMFS listed the Middle Columbia River steelhead DPS as threatened on January 5, 2006 (71 FR 834). Rainbow trout and redband trout are under the jurisdiction of the states unless they are listed, when they come under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). This recovery plan addresses steelhead and not rainbow trout, as is consistent with the 2006 ESA listing decision.

Context of Plan Development

While NMFS is directly responsible for ESA recovery planning for salmon and steelhead, NMFS believes that ESA recovery plans for salmon and steelhead should be based on the many state, regional, tribal, local, and private conservation efforts already underway throughout the region. Local support of recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential. NMFS therefore supports and participates in locally led collaborative efforts to develop recovery plans that involve local communities, state, tribal, and Federal entities, and other stakeholders.

This Plan is the product of a collaborative process initiated by NMFS with assistance from the Middle Columbia Recovery Forum (Mid-C Forum), a group convened by NMFS to provide input on the development of the DPS recovery plan. NMFS developed this Plan by drawing upon the best available scientific information provided by the four regional recovery plans included as appendices to this Plan (i.e. the management unit plans, described below and in Section 1.6.), and by a regional team of scientists (the Interior Columbia Technical Recovery Team, described below). The Draft Plan went through repeated reviews and revisions in response to comments from both the scientific team and the Mid-C Forum. Participants in the Mid-C Forum include the Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), the Yakama Nation, Confederated Tribes of the Warm Springs Indian Reservation, Confederated Tribes of the Umatilla Indian Reservation, Washington Governor's Salmon Recovery Office, Oregon Governor's Natural Resources Office, Snake River Salmon Recovery

Board, Yakima Basin Fish and Wildlife Recovery Board, US Bureau of Reclamation (BOR), US Fish and Wildlife Service (USFWS), US Forest Service (USFS), US Army Corps of Engineers (COE), Klickitat County, and NMFS Northwest Region. The Draft Recovery Plan, including the four management unit plans and two scientific reports (McClure et al. 2003; ICTRT 2007a) that provide the scientific basis for the Plan, was made available for public review as a Proposed Recovery Plan. NMFS revised the Proposed Plan in response to public comments, including comments from the ICTRT as peer reviewers. The responses to public comments are available on the NMFS website, at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Mid-Columbia/Mid-Col-Plan.cfm.

Tribal Trust and Treaty Responsibilities

Northwest Indian Tribes have legally enforceable rights reserving to them a share of the salmon harvest. A complex history of treaties, executive orders, legislation, and court decisions have culminated in the recognition of tribes as co-managers who share management responsibilities and rights for fisheries in the Columbia Basin.

Ensuring a sufficient abundance of salmon and steelhead to sustain harvest is an important element in fulfilling trust responsibilities and treaty rights as well as garnering public support for recovery plans. ESA and tribal trust responsibilities complement one another. Both depend on a steady upward trend toward ESA recovery and delisting in the near term, while making aquatic habitat, harvest, and land management improvements for the long term.

Recovery Domains and Technical Recovery Teams

Currently, there are 19 ESA-listed ESUs/DPSs of Pacific salmon and steelhead in the Pacific Northwest. For the purpose of recovery planning for these species, NMFS Northwest Region designated five geographically based "recovery domains" (Figure ES-2). The range of the Middle Columbia River steelhead DPS is located in the Middle Columbia sub-domain of the Interior Columbia domain.

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each Technical Recovery Team (TRT) was to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. The Interior Columbia TRT (ICTRT) includes biologists from NMFS, states, tribes, and academic institutions.

Viable Salmonid Populations

All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population viability criteria – criteria that may be used, along with criteria based on mitigation of the factors for decline, in determining whether a species has recovered sufficiently to be downlisted or delisted. These principles are described in a NMFS technical memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000).

Viable salmonid populations (VSP) are defined in terms of four parameters: abundance, productivity (growth rate), spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework, based on data availability, the unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective

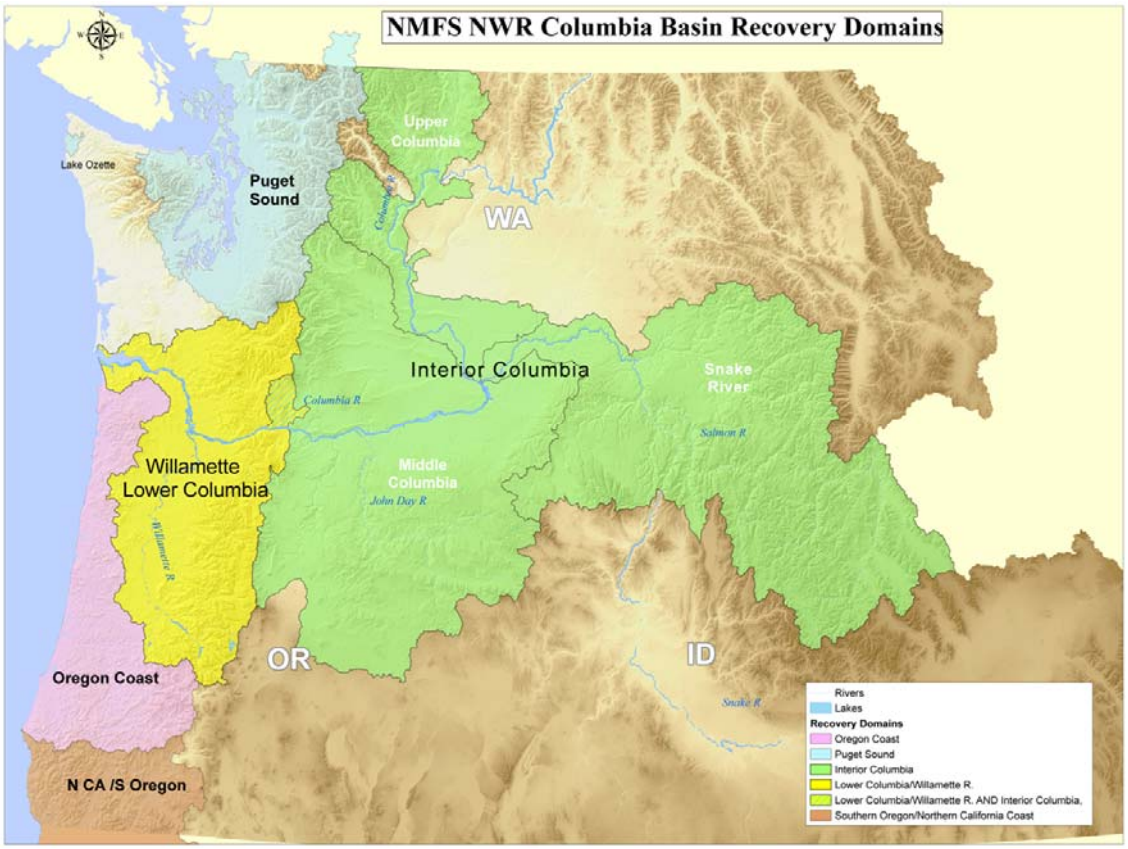


Figure ES-2. Columbia Basin Recovery Domains for NMFS Northwest Region.

experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs are working from a common scientific foundation. Viability criteria are an important part of recovery goals, as described later in this summary.

Management Units

In each domain, NMFS worked with state, tribal, local, and other Federal entities to develop planning forums that build to the extent possible on ongoing, locally led recovery efforts. NMFS defined "management units" based on jurisdictional boundaries as well as areas where local planning efforts were underway (Figure ES-3). It can be seen from the figure that the management units do not necessarily correspond to biological units, such as steelhead populations, but are defined for planning and administrative purposes. The Middle Columbia management units are (1) Oregon; (2) Washington Gorge, which, in turn, is subdivided into three planning areas, White Salmon, Klickitat, and Rock Creek; (3) Yakima subbasin; and (4) Southeast Washington.

Management Unit Recovery Plans and the Modules

Although NMFS has prepared this plan for the entire DPS, the management unit plans (Appendices A-E) are the work of local groups and county, state, Federal, and tribal entities within the Middle Columbia River region on both sides of the river. The management unit plans built on existing recovery plans, in particular, the Northwest Power and Conservation Council's subbasin plans, and targeted the specific ESA recovery needs of Middle Columbia steelhead. In addition, to deal with system effects that transcend the individual subbasins, domains, and management units, NMFS prepared two recovery planning modules: the Hydro Module (Appendix F), which summarizes the 2008 Federal Columbia River Power System Biological Opinion, and the Estuary Module (Appendix G), prepared by NMFS in collaboration with the Lower Columbia River Estuary Partnership.

- **Oregon Management Unit:** ***Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment (Oregon Steelhead Recovery Plan) (Appendix A)***

The Oregon Department of Fish and Wildlife (ODFW) is the lead for the Oregon Steelhead Recovery Plan. ODFW drew together three groups to help with the plan: the Middle Columbia Recovery Planning Team, made up of ODFW staff biologists and representatives from eight state natural resource agencies; a planning forum, the Middle Columbia Sounding Board, made up of representatives of local communities, agricultural water users, Federal and non-Federal land managers, governing bodies, tribes, and industry and environmental interests; and an Expert Panel of 12 biologists to examine limiting factors and threats for the 10 independent steelhead populations in Oregon.

- **Washington Gorge Management Unit:** ***Recovery Plans for the Klickitat River (Appendix B) and Rock Creek (Appendix C) subbasin populations of Middle Columbia River steelhead (the Klickitat Plan and the Rock Creek Plan)***

Since there is not presently a Washington State sponsored salmon recovery planning board for this area, NMFS staff drafted the Klickitat and Rock Creek plans in collaboration with the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal agencies, state agencies, local governments, and the public. The White Salmon River subbasin, which historically supported a population of Middle Columbia River steelhead, is also part of this management unit, but the recovery plan for that population will be finalized as part of the Lower Columbia ESA Recovery Plan. Single populations of three listed ESUs of salmon (Lower Columbia River Chinook, Lower Columbia River Coho, and Columbia River Chum) spawn in the White Salmon River subbasin in addition to steelhead. The need for an ecosystem approach warrants addressing in one single plan all the listed salmonids that spawn in the White Salmon subbasin. However, the delisting criteria, actions, and costs for the White Salmon steelhead are included in this DPS plan in order to have all the information on the Middle Columbia steelhead DPS in one place.

- **Southeast Washington Management Unit:** ***Snake River Salmon Recovery Plan for Southeast Washington (Southeast Washington Plan) (Appendix D)***

The Snake River Salmon Recovery Board developed the recovery plan for the Southeast Washington management unit, which is called the Southeast Washington Plan here in order to differentiate it from the forthcoming recovery plan for the five species of listed salmon and steelhead in the Snake River region (which includes parts of Washington, Oregon, and Idaho). The Snake River Salmon Recovery Board consists of representatives of the Confederated Tribes of the Umatilla Indian Reservation; a county commissioner and citizen representative from Asotin, Columbia, Garfield, Walla Walla and Whitman counties; a land owner representative from Asotin, Columbia and Garfield counties; and the Walla Walla county irrigation district. The Board appointed a Regional Technical Team for technical and scientific assistance.

- **Yakima Management Unit:** ***Yakima Steelhead Recovery Plan (Appendix D)***

The Yakima Basin Fish and Wildlife Recovery Board (YBFWRB), which includes representatives from the Yakama Nation, Benton, Kittitas, and Yakima counties, and 18 of the 24 municipalities in the Yakima Basin, developed the Yakima Steelhead Recovery Plan (available at www.ybfwrb.org).

- **Hydro Module (Appendix F)**

The Hydro Module summarizes the general effects of Columbia River mainstem hydropower projects on all 13 ESA-listed salmonids in the Columbia basin, including the limiting factors and threats and expected actions (including site-specific management actions), or strategy options, to address those threats. This module supports recovery plans for the Snake River, Upper Columbia, Middle Columbia, Lower Columbia, and Upper Willamette River species. It is a synthesis of information that has undergone public processes for review, including, but not limited to, the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion, Federal Energy Regulatory Commission (FERC) licensing proceedings, and Habitat Conservation Plans (HCPs). This module may be updated as additional information becomes available.

- **Estuary Module (Appendix G)**

The Estuary Module focuses on habitat in the lower Columbia River below Bonneville Dam and how that habitat affects the survival of ESA-listed chum, steelhead, Chinook, and coho from throughout the Columbia River basin. It identifies and prioritizes limiting factors and threats in the estuary, then identifies 23 broad actions whose implementation would reduce the threats and thus increase survival of salmon and steelhead during their time in the estuary. The module also estimates the cost of implementing each action over a 25-year period. A description of monitoring, research, and evaluation needs that are appropriate to the management actions is included as an appendix to the module.

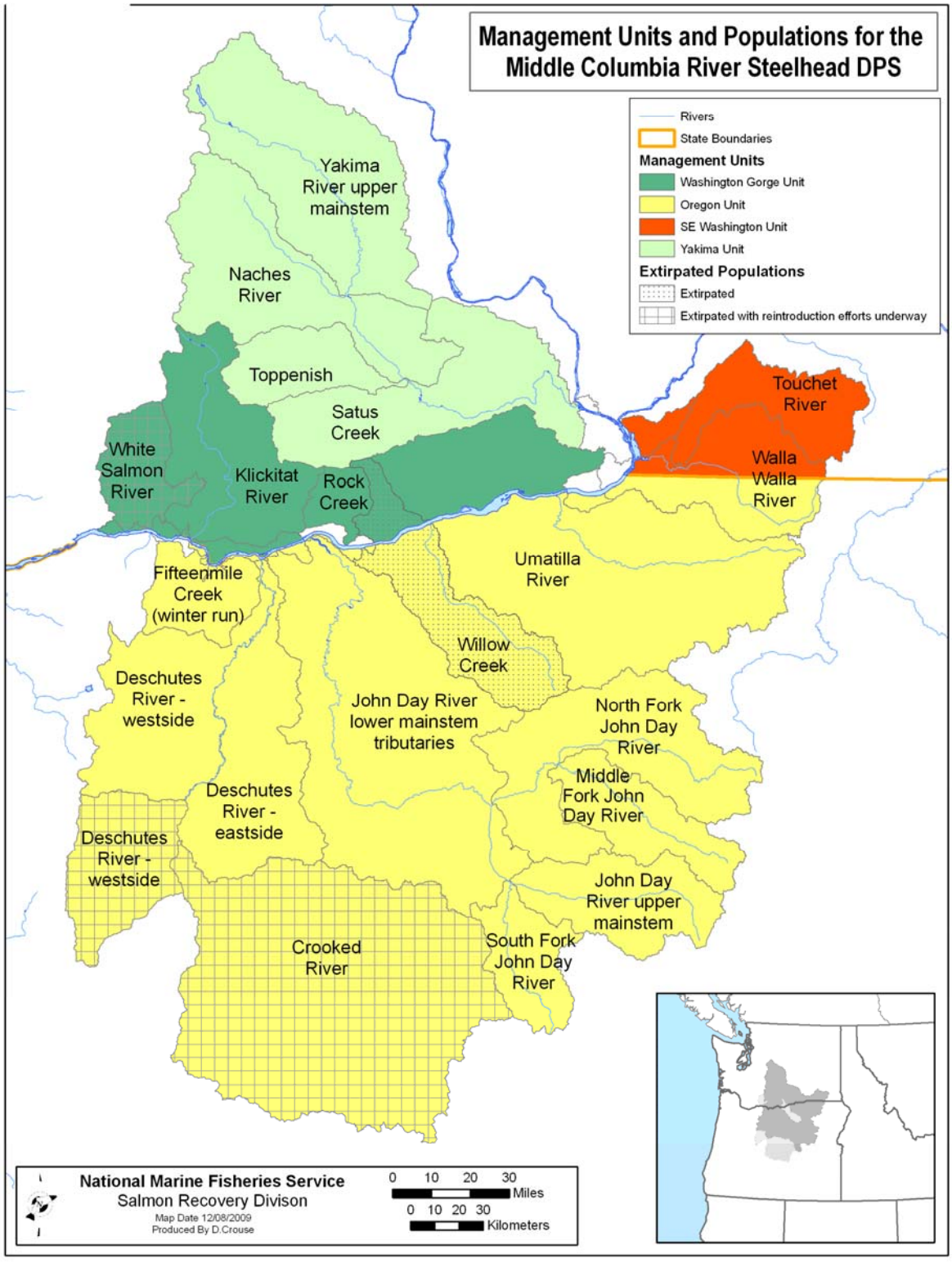


Figure ES-3. Management Units and Populations for the Middle Columbia River Steelhead DPS.

Important Concepts in Steelhead (and Salmon) Biology

Salmonid species' homing propensity (their tendency to return to the locations where they originated) creates unique patterns of genetic variation and connectivity that mirror the distribution of their spawning areas across the landscape. Diverse genetic, life history, and morphological characteristics have evolved over generations, creating runs highly adapted to diverse environments. It is this variation that gives the species as a whole the resilience to persist over time.

Historically, a salmon ESU or steelhead DPS typically contained multiple populations connected by some small degree of genetic exchange that resulted from some spawners "straying" into neighboring streams. Thus, the overall biological structure of the ESU/DPS is hierarchical; spawners in the same area of the same stream will share more characteristics than those in the next stream over. Fish whose natal streams are separated by hundreds of miles will have less genetic similarity.

Definition of Evolutionarily Significant Units/Distinct Population Segments

An ESU is defined as a group of Pacific salmon that is "substantially reproductively isolated from other conspecific units and represents an important component of the evolutionary legacy of the species" (Waples et al. 1991). A "population segment" is considered distinct (a DPS and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics; or if it occupies an unusual or unique ecological setting; or if its loss would represent a significant gap in the species' range (71 FR 834).

ESUs/DPSs may contain multiple populations that are connected by some degree of genetic exchange through straying, and hence may have a broad geographic range across watersheds and river basins.

Major Population Groups

Within an ESU/DPS, independent populations can be grouped into larger populations that share similar genetic, geographic, and/or habitat characteristics (McClure et al. 2003). These "major groupings" of populations (MPGs) are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between ESUs/DPSs.

Independent Populations

McElhany et al. (2000) defined an independent population as follows:

> *"…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season."*

Abundance and Productivity

Abundance refers to naturally produced spawners (adults on the spawning ground), measured over a time series, i.e. some number of years. The ICTRT often uses a recent 10- or 12-year geometric mean of natural spawners as a measure of current abundance.

The productivity of a population (the average number of surviving offspring per parent) is a measure of the population's ability to sustain itself. Productivity can be measured as spawner:spawner ratios (returns per spawner or recruits per spawner) (or adult progeny to parent), annual population growth rate, or trends in abundance. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, typically subject to a high degree of annual variability and sampling-induced uncertainties.

Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations.

Spatial Structure and Diversity

Spatial structure and diversity considerations are combined in the evaluation of a salmonid population's status because they often overlap. A population's spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000, p. 18). Diversity refers to the distribution of traits within and among populations. Some traits are completely genetically based, while others, including nearly all morphological, behavioral, and life history traits, vary as a result of a combination of genetic and environmental factors (ibid. p. 19).

Populations with restricted distribution and few spawning areas are at a higher risk of extinction as a result of catastrophic environmental events, such as a landslide, than are populations with more widespread and complex spatial structures. Population-level diversity is similarly important for long-term persistence. Populations exhibiting greater diversity are generally more resilient to short-term and long-term environmental changes.

Middle Columbia Steelhead Populations and Major Population Groups

The ICTRT (McClure et al. 2003) identified 20 historical populations of Middle Columbia steelhead, shown in Figure ES-4. This identification was based on genetic information, geography, life history traits, morphological traits, and population dynamics. Seventeen of these populations are extant, and three extirpated (White Salmon River, Deschutes Crooked River above Pelton Dam, and Willow Creek).

The ICTRT stratified the Middle Columbia River steelhead populations into MPGs based on ecoregion characteristics, life history types, and other geographic and genetic considerations. It identified four MPGs: Cascades Eastern Slope Tributaries, Yakima Basin, John Day Basin, and Umatilla/Walla Walla. The John Day River MPG is wholly within Oregon and the Yakima Basin MPG is wholly within Washington. The other two include populations on both sides of the Oregon/Washington boundary.

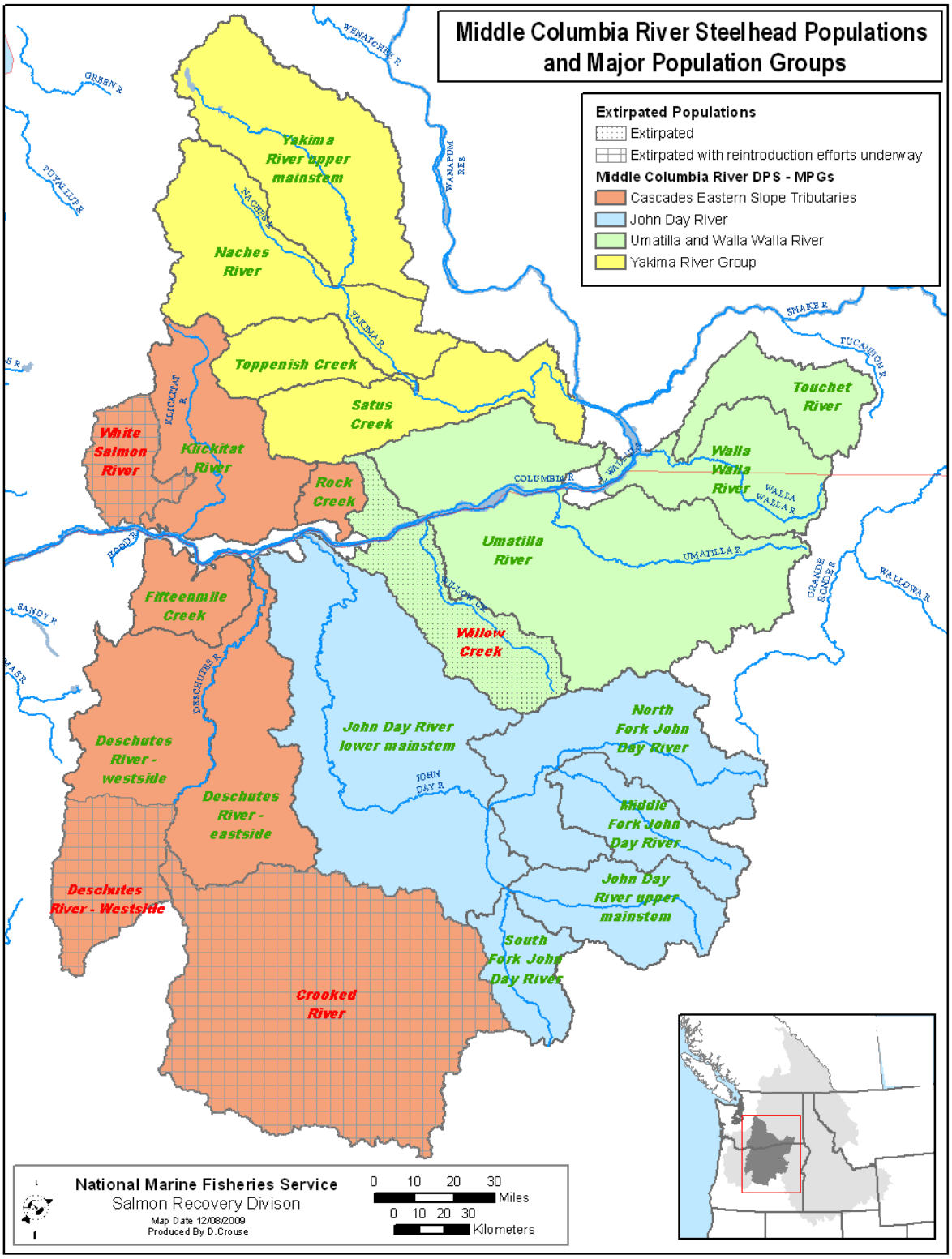


Figure ES-4. Middle Columbia River Steelhead Populations and Major Population Groups.

Recovery Goals and Delisting Criteria

The recovery goals that are incorporated into a locally developed recovery plan may include delisting and/or other "broad sense" goals that may go beyond the requirements for delisting to address, for example, other legislative mandates or social, economic, or ecological values. NMFS' delisting criteria may include both technical and policy considerations, and must meet the ESA requirements. A third term used in this recovery plan is recovery "scenarios" (Section 3.1.4). Recovery scenarios are combinations of viability status for individual populations within the DPS that will meet the ICTRT criteria for overall DPS viability.

Recovery criteria are of two kinds: the biological viability criteria, which deal with the VSP parameters at the population, MPG, and DPS levels, and the "threats" criteria, which relate to the five listing factors detailed in the ESA (see Sections 1.1 and 3.3 of this Plan). The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B) for the delisting decision.

The delisting criteria are based on the best available scientific information and incorporate the most current understanding of the DPS and the threats it faces. As this recovery plan is implemented, additional information will become available that can increase certainty about whether the threats have been abated, whether improvements in population and DPS status have occurred, and whether linkages between threats and changes in salmon status are understood. These criteria will be assessed through an adaptive management program under development for the Plan, and NMFS may review the criteria if appropriate during its 5-year reviews of the DPS.

Biological Viability Criteria

In 2007, the ICTRT completed its Technical Review Draft of *Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs* (ICTRT 2007a). Biological viability criteria describe DPS characteristics associated with a low risk of extinction for the foreseeable future. These criteria are expressed in terms of the VSP parameters of abundance, productivity, spatial structure, and diversity, according to guidelines developed by NOAA's Northwest Fisheries Science Center and published as a NOAA Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000; ICTRT 2007a). The ICTRT calculated varying levels of risk of extinction and related the risk levels to their criteria.

DPS Viability Criterion

Since MPGs are geographically and genetically cohesive groups of populations, they are critical components of ESU or DPS spatial structure and diversity. Having all MPGs within a DPS at low risk provides the greatest probability of persistence for the DPS.

DPS Viability Criterion (ICTRT 2007a)
All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS[1] should be at low risk.

[1] The Middle Columbia steelhead DPS has four extant and no extirpated MPGs. The three extirpated populations are addressed as part of the MPG-level criteria.

MPG Viability Criteria

MPG viability depends on the number, spatial arrangement, and diversity associated with its component populations.

MPG-Level Viability Criteria (ICTRT 2007a)

The following five criteria should be met for an MPG to be regarded as at low risk (viable):

1. At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.
2. At least one population should be classified as "Highly Viable."
3. Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as "Very Large," "Large," or "Intermediate," generally reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.
4. All major life history strategies (e.g. spring and summer-run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.
5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU/DPS recovery.

The DPS criterion requiring viable populations in each of the extant MPGs would result in sustainable production across a substantial range of environmental conditions. The presence of viable populations across MPGs would preserve a high level of diversity within the DPS, thereby promoting long-term evolutionary potential for adaptation to changing conditions. The presence of multiple, relatively nearby, viable and maintained populations acts as protection against long-term impacts of localized catastrophic loss by serving as a source of re-colonization (ICTRT 2007a).

Population Viability Criteria

To be determined to be viable, populations should meet criteria for all four VSP parameters (abundance, productivity, spatial structure, and diversity). The abundance and productivity criteria are related to population size.

Population Size

The ICTRT developed criteria for characterizing the relative size and complexity of Interior Columbia Basin steelhead populations based on their analysis of the intrinsic or historical potential habitat available to the population (ICTRT 2005). Middle Columbia steelhead spawn in a wide range of tributary drainage areas, from small creeks, e.g. Fifteenmile Creek or Rock Creek, to very large rivers, such as the Lower John Day. The ICTRT categorized historical

population sizes as Basic, Intermediate, Large, and Very Large, and set minimum abundance thresholds for viable steelhead populations of each type. As explained in Section 2.4.1, abundance and productivity are linked, within limits; above a certain threshold, higher productivity can compensate for lower abundance and vice versa. Table ES-1 shows the minimum abundance and productivity thresholds for the Middle Columbia steelhead populations to have a 95 percent probability of persistence for the next 100 years.

Table ES-1. Middle Columbia Steelhead size categories (ICTRT 2007a).

Major Population Grouping	Population	Population Size	Abundance Threshold	Productivity Threshold
Cascades Eastern Slope Tributaries	White Salmon (functionally extirp.)	Basic	500	1.56
	Klickitat R.	Intermediate	1000	1.35
	Fifteenmile Cr.	Basic	500	1.56
	Deschutes R. East	Intermediate	1000	1.35
	Deschutes R. West	Large[2]	1500	1.26
	Rock Cr.	Basic	500	1.56
	Crooked River (Extirp.)	Very Large	2250	1.19
John Day River	Lower Mainstem JD	Very Large	2250	1.19
	North Fork John Day	Large	1500	1.26
	Middle Fork John Day	Intermediate	1000	1.35
	South Fork John Day	Basic	500	1.56
	Upper Mainstem JD	Intermediate	1000	1.35
Umatilla / Walla Walla Rivers	Umatilla R.	Large	1500	1.26
	Walla Walla R.	Intermediate	1000	1.35
	Touchet R.	Intermediate	1000	1.35
	Willow Crk. (Extirp.)	Intermediate	1000	1.35
Yakima River Group	Satus Cr.	Intermediate[3]	1000	1.35
	Toppenish Cr.	Basic	500	1.56
	Naches R.	Large	1500	1.26
	Upper Yakima	Large	1500	1.26

Abundance and productivity

The ICTRT defined abundance and productivity criteria for Middle Columbia steelhead populations (ICTRT 2005 and 2007a) based on analyses of the intrinsic potential of the historically available habitat, the locations and sizes of major and minor spawning areas, and, within these areas, the abundance and productivity relationships that would result in a probability of low risk of extinction within 100 years (see Table ES-1 above). The abundance "thresholds" shown in the table represent the number of spawners needed for a population of the given size category to achieve the 5 percent (low) risk level at a given productivity.

[2] This population is treated as Intermediate in size with respect to abundance and productivity criteria because of constraints on currently accessible habitat (i.e. Pelton Dam).

[3] For the historical population analysis, the ICTRT included the mainstem Yakima habitat below the confluence of Satus Creek in the Satus Creek population, making it Intermediate in size. However, if the mainstem component is lumped instead with mainstem Yakima River habitat upstream of Satus, the Satus Creek population would drop to Basic size. The Yakima Steelhead Recovery Plan discusses this question in more detail.

Spatial structure and diversity

The spatial structure and diversity criteria are specific to each population, and are based on historical spatial distribution and diversity, to the extent these can be known or inferred. The ICTRT cautions that there is a good deal of uncertainty in assessing the status of spatial structure and diversity in a population (ICTRT 2007a; McElhany et al. 2000).

Recovery Scenarios

The risk levels of the populations within the DPS collectively determine MPG viability and, in turn, the likely persistence of the DPS. The ICTRT recommended that all MPGs in a DPS should be viable; however, it may not be necessary for all of the populations to attain the lowest risk level. There may be more than one way for a DPS to meet the viability criteria.

The ICTRT, in a January 8, 2007 technical memorandum (ICTRT 2007a), offered a detailed discussion of possible recovery scenarios for each MPG. They cautioned against closing off the options for any population prematurely, however, because of the many uncertainties in predicting the biological response to recovery actions. The ICTRT concluded that "a low risk strategy will target more populations than the minimum for viability" (ICTRT 2007a).

The management unit plans include locally determined recovery goals as well as viability criteria for the individual steelhead populations and MPGs in each management unit. Most of the plans also provide targets or objectives to measure progress within specified time frames, e.g. 10 to 50 years.

Threats Criteria

At the time of a delisting decision for the Middle Columbia steelhead, NMFS will examine whether the section 4(a)(1) listing factors have been addressed. To assist in this examination, NMFS will use the listing factors (or threats) criteria described in Section 3.3 of this plan, in addition to evaluation of biological recovery criteria and other relevant data and policy considerations. It is possible that currently perceived threats will become insignificant in the future because of changes in the natural environment or changes in the way threats affect the entire life cycle of salmon. Consequently, NMFS expects that the relative priority of threats will change over time and that new threats may be identified. During the status reviews, NMFS will evaluate and review the listing factor criteria as they apply at that time. NMFS expects that if the proposed actions described in the Plan are implemented, they will make substantial progress toward meeting the listing factor (threats) criteria for the Middle Columbia steelhead.

Current Status Assessment

The status of a salmonid ESU or DPS is expressed in terms of likelihood of persistence over 100 years, or in terms of risk of extinction within 100 years. The ICTRT defines viability at two levels: less than 5 percent risk of extinction within 100 years (viable) and less than 1 percent risk of extinction within 100 years (highly viable). A third category, "maintained," represents a less than 25 percent risk. The risk level of the DPS is built up from the aggregate risk levels of the populations and MPGs. All four VSP parameters must be taken into account to determine the risk level.

Table ES-2 summarizes current status of the Middle Columbia steelhead populations, showing 10-year geometric mean abundance by population, estimated productivity, and the minimum abundance threshold needed for long-term viability. The table also includes the 10-year geometric mean proportion of hatchery spawners for the populations where data are available, and the risk ratings of high, moderate, low, and very low, for abundance and productivity combined, and spatial structure and diversity combined. Figure ES-5 is a matrix combining all four parameters to illustrate the overall current risk rating of each population.

Current Population Status

According to the ICTRT viability criteria, the majority of naturally spawning Middle Columbia steelhead populations are rated at moderate risk for all four VSP parameters – abundance, productivity, spatial structure, and diversity (Table ES-2 and Figure ES-5). This DPS includes one highly viable population (North Fork John Day), two viable (Fifteenmile Creek and Deschutes River Eastside), and three at high risk of extinction within 100 years (Deschutes Westside, Upper Yakima Mainstem, and Naches River).

MPG Status

The viability ratings of the component populations of each Middle Columbia steelhead MPG are shown in Figure ES-5. None of the MPGs as a whole reaches low risk status according to the ICTRT's MPG-level criteria.

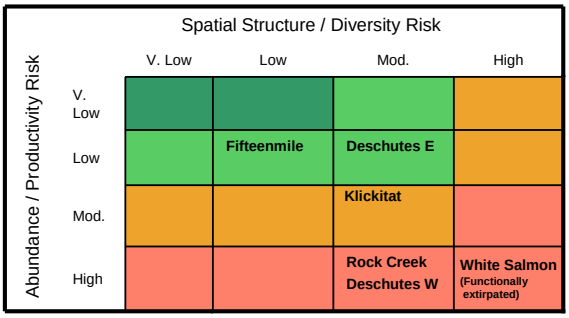
DPS Status

The ICTRT's DPS-level viability criterion is that all extant MPGs and any extirpated MPGs critical for proper functioning of the DPS should be at low risk (ICTRT 2007a). Thus, the Middle Columbia steelhead DPS does not currently meet viability criteria based on the determination that the four component MPGs are not at low risk.

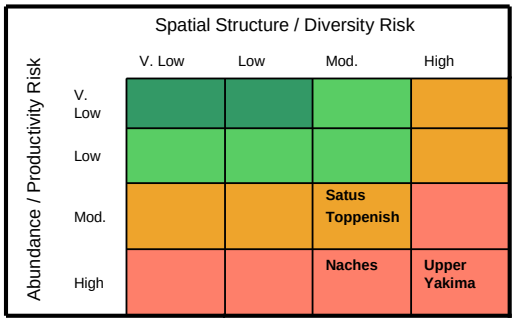
Table ES-2. Middle Columbia River steelhead DPS populations: summary of abundance, productivity, risk ratings, and minimum abundance thresholds (Source: ICTRT 2007a and 2008). (Numbers subject to periodic updates as additional information becomes available.)

Population	*Abundance Threshold*[4]	*Size Category*	*Run Timing*	*10-year Geomean abundance*	*Abundance Range*	*10-yr Hatchery Fraction*[5]	*Produc-tivity*[6]	*Productivity Standard Error*	*A&P Risk*[7] *Rating*	*SS/DRisk Rating*
Cascades East Slope MPG										
Deschutes (Westside)	1000[8]	Large (Inter)	Summer	456	108-1283	0.26	1.05	0.15	H	M
Deschutes (Eastside)	1000	Intermed.	Summer	1599	299-8274	0.39	1.89	0.27	L	M
Klickitat River	1000	Intermed.	Wtr & Smr	Insufficient data						M
Fifteenmile Creek	500	Basic	Winter	703	231-1922	0	1.82	0.20	L	L
Rock Creek	500	Basic	Summer	Insufficient data					H	M
White Salmon	500	Basic		Functionally extirpated						N/A
Crooked River	2250	Very Large	Summer	Extirpated						
Yakima River MPG										
Upper Yakima River	1500	Large	Summer	85	34-283	0.02	1.12	0.22	H	H
Naches River	1500	Large	Summer	472	142-1454	0.06	1.12	0.22	H	M
Toppenish River	500	Basic	Summer	322	44-1252	0.06	1.60	0.30	M	M
Satus Creek (trib only)	1000	Intermed.	Summer	379	138-1000	0.06	1.73	0.14	M	M
John Day River MPG							M			
Lower Mainstem John Day	2250	Very Large	Summer	1800	563-6257	0.1	2.99	0.24	M	M
North Fork John Day	1500	Large	Summer	1740	369-10,235	0.08	N/A 2.41	0.22	VL	L
Upper Mainstem John Day	1000	Intermed.	Summer	524	185-5169	0.08	2.14	0.33	M	M
Middle Fork John Day	1000	Intermed.	Summer	756	195-3538	0.08	2.45	0.16	M	M
South Fork John Day	500	Basic	Summer	259	76-2729	0.08	2.06	0.27	M	M
Umatilla/Walla Walla MPG										
Umatilla River	1500	Large	Summer	1472	592-3542	0.36	1.50	0.15	M	M
Walla Walla Mainstem	1000	Intermed.	Summer	650	270-1746	0.02	1.34	0.12	M	M
Touchet River	1000	Intermed.	Summer	Insufficient data					H	M
Willow Creek	1000	Intermed.	Summer	Extirpated					N/A	N/A

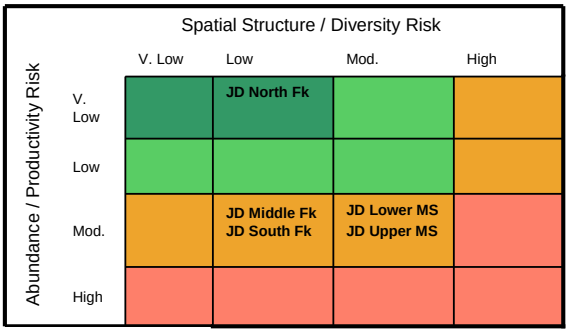
[4] Abundance threshold for viability based on habitat intrinsic potential
[5] Average proportion of hatchery spawners over most recent 10 years in the data series.
[6] Geomean return per spawner calculated over most recent 20 years in data series.
[7] H = high risk, M= moderate risk, L = low risk, VL = very low risk
[8] The Deschutes Westside steelhead population is classified as Large in terms of spatial structure, but its abundance threshold may be considered 1000 or 1500 because of "currently accessible area" considerations. See ODFW 2009.



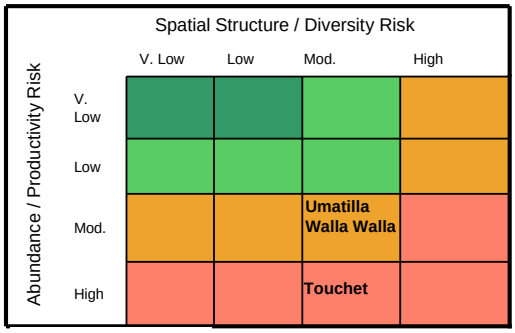
Cascades Eastern Slopes Tributaries Major Population Group.



Yakima River Major Population Group.



John Day Basin Major Population Group.



Umatilla/Walla Walla Major Population Group.

Figure ES-5. Viability Ratings for Middle Columbia Steelhead Populations by MPG (developed by NMFS based on ICTRT 2008).

Gap Analysis

The ICTRT assessed the difference between a listed species' or population's current status for abundance and productivity and the viability criteria. This difference is called the "gap." The gap, as used in this plan, is a measure, although it is inevitably imprecise, of the improvement in survival needed to meet viability criteria. As such, it is also an indicator of the level of effort needed to achieve recovery.

The ICTRT calculated the gap for each extant Middle Columbia steelhead population based on current abundance and productivity for the listed salmon and steelhead in the Interior Columbia Basin (ICTRT 2007b). They estimated the minimal survival rate changes needed for Middle Columbia steelhead populations to meet the abundance and productivity viability criteria for a 5 percent risk of extinction in a 100-year time frame.

In addition, the ICTRT (2007b) estimated gaps under three different early-ocean survival scenarios; historical ocean conditions (ocean conditions that fish experienced over the past 60 years), pessimistic ocean conditions (ocean conditions experienced by the 1975-1997 brood years), and recent ocean conditions (ocean conditions experienced by fish during the 20-year assessment period). The ICTRT also estimated gaps assuming three different hydropower scenarios. However, only the base hydro condition, which assumed that survival rates from the most recent 20 years would continue into the future, is reported here. (See NMFS 2008a for details on survival through the FCRPS under proposed improvements.)

A positive number, e.g. 21 percent gap for Cascades Eastern Slope MPG, means the population's overall survival needs to increase 21 percent over current conditions to achieve viability criteria. A zero or negative number would mean there is no gap – the population currently meets viability criteria.

The analysis showed that none of the MPGs would be able to achieve a 5 percent or less risk of extinction over 100 years without recovery actions (Table ES-3). The Yakima Basin MPG shows the largest gap (77 percent) and also contains two historically large populations now at high risk of extinction, the Upper Yakima River and Naches River populations.

Table ES-3. Median survival gap for the major population groups of the Middle Columbia Steelhead DPS (assuming recent ocean and base hydrosystem conditions and 5 percent risk).

Cascades Eastern Slope MPG	21 percent
John Day MPG	9 percent
Umatilla/Walla Walla MPG Sufficient data for only two of the three populations: Umatilla Walla Walla	 9 percent 34 percent
Yakima MPG	77 percent

It is important to include measures to address spatial structure and diversity (SS/D) risks in recovery planning. As described in Section 4.3 of this Plan, the ICTRT analyzed a population's spatial structure and diversity in terms of two goals: maintaining natural rates and levels of spatially mediated processes, and maintaining natural patterns of variation. The team developed a scoring system to derive a composite spatial structure and diversity rating for each population (ICTRT 2008). Using this method, the ICTRT rated only the Fifteenmile Creek and North Fork John Day populations at low risk of extinction with regard to spatial structure and diversity. The Upper Yakima River is at high SS/D risk, and the 15 other populations are rated at moderate risk. The Middle Columbia River steelhead DPS cannot reach viable status without closing these gaps as well as those identified in terms of abundance and productivity.

Limiting Factors and Threats

The reasons for a species' decline are generally described in terms of limiting factors and threats. NMFS defines limiting factors as the biological and physical conditions that limit a species' viability – e.g., high water temperature – and defines threats as those human activities or natural processes that cause the limiting factors. For example, removing the vegetation along the banks of a stream can cause higher water temperatures, because the stream is no longer shaded. The threats contributing to the limiting factors and causes for a species' decline are often described in terms of the "four Hs" – habitat (usually relating to the effects of land use and tributary water use), hydropower, harvest, and hatcheries. While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are typically legitimate and necessary human activities that may at times have unintended negative consequences on

fish populations—and that can also be managed in a manner that minimizes or eliminates the negative impacts.

Designing effective recovery strategies and actions requires understanding limiting factors and threats across the species' entire life cycle and across the four Hs. This plan describes limiting factors and threats for the Middle Columbia steelhead DPS as a whole at a general level, and notes the most salient specific conditions that affect individual populations and limit the viability of specific MPGs. More detail is available in the individual management unit plans (Appendices A through E).

Limiting Factors and Threats for the DPS

At a general level, based on information from the ICTRT and the four management unit plans, the major factors limiting the viability of Middle Columbia steelhead populations are *degraded tributary habitat*, *impaired fish passage in the mainstem Columbia River and tributaries, hatchery-related effects, and predation/competition/disease.* Two other factors, degradation of estuarine and nearshore marine habitat and harvest-related effects, pose some risk to steelhead viability for the entire DPS, but less than the other factors. Climate change represents a potentially significant threat to recovery of Middle Columbia steelhead populations (see ISAB 2007). In Section 6.3 of this Plan, the limiting factors and threats are described in more detail, addressing all the Hs and all life stages. Sources for this information include the management unit plans (Appendices A through E); the Biological Opinion for the Federal Columbia River Power System (FCRPS BiOp) (NMFS 2008a), particularly the BiOp's Supplemental Comprehensive Analysis and its appendices; the Hydro Module (NMFS 2008c) (Appendix F of this Plan), and the Estuary Module (NMFS 2007) (Appendix G of this Plan).

Degraded tributary habitat. Tributary habitat degradation from past and/or present land use remains a key concern for all of the populations. Today, nearly all historical habitat lies in areas modified by human settlement and activities. In many areas, the contemporary watershed conditions created by past and current land use practices are so different from those under which native fish species evolved that they now pose a significant impediment to achieving recovery. The management unit plans contain detailed descriptions of tributary habitat threats and limiting factors.

Impaired fish passage. Impaired fish passage is identified as a key or secondary limiting factor for all populations of Middle Columbia steelhead. Dams, culverts, seasonal pushup dams, and unscreened diversions can directly prevent migration; seasonal areas of high water temperature, low flow, or dewatering can also function as barriers. There are various kinds of dams and other barriers in tributaries throughout the basin, and all populations of Middle Columbia steelhead use the mainstem Columbia River to migrate to and from the ocean. All are affected by the mainstem Federal dams. Development and operation of the mainstem Columbia River hydropower system significantly alters travel conditions in the mainstem Columbia River, resulting in direct mortality of both upstream migrating adults and downstream migrating steelhead kelts, and direct and indirect mortality for downstream migrants (juveniles). The hydro system also changes the hydrograph, depleting historically available nutrients, changing water temperatures, and degrading rearing and food resources for both presmolts and smolts in the Columbia.

Changes in the hydrograph leave steelhead more vulnerable to bird and fish predation in the Columbia River estuary and mainstem. In addition, broad deltas have been created at the mouths of tributaries where fine sediment has been deposited. These conditions have resulted in increased non-native piscivorous and avian predation on juveniles. All these impacts increase somewhat for each population in direct relation to the number of dams that fish must pass during their migration to and from the Pacific Ocean. Middle Columbia River steelhead populations pass from one to four Federal dams. Survival is estimated at 90, 73, 54, and 48 percent, respectively, for juvenile steelhead passage through one to four dams (see Table 6-2). Adult steelhead survival is relatively high through the lower Columbia River dams and reservoirs – estimated at 98.5 to 95 percent for one to four dams (Table 6-3) – as a result of dam operations and effective fish ladders.

Hatchery effects. Hatchery fish that stray into Middle Columbia tributaries and spawn naturally may represent a serious threat to steelhead recovery. More than 100 hatchery programs operate in the Columbia Basin above Bonneville Dam, mostly for the purpose of providing fish for harvest to mitigate losses caused by the FCRPS. Some hatchery programs may provide conservation benefits; however, hatchery programs also pose threats to natural-origin steelhead in some Middle Columbia watersheds. Hatchery-induced genetic change can reduce the fitness of both hatchery and natural-origin fish in the wild, and hatchery-induced ecological effects (competition for food and space) can reduce population productivity and abundance. In particular, hatchery programs designed to return summer steelhead to upstream Columbia River tributaries result in substantial numbers of stray hatchery steelhead spawning naturally among several Middle Columbia populations. Concern exists regarding the continuing detrimental impact of these stray out-of-DPS hatchery fish in natural spawning areas on the genetic diversity and productivity of naturally produced Middle Columbia River steelhead populations.

Predation, competition, disease. Anthropogenic changes in the Columbia River have altered the relationships between salmonids and other fish, bird, and pinniped species, resulting in changed opportunities for predation by non-native piscivorous fish, avian species such as terns and cormorants, and California sea lions below Bonneville Dam. Hatchery releases of juvenile steelhead may result in competition with natural-origin steelhead for food and other resources. Steelhead can be infected by a variety of bacterial, viral, fungal, and microparasitic pathogens. Numerous diseases may result from pathogens that occur naturally in the wild or that may be transmitted to wild fish via infected hatchery fish. However, studies have shown that naturally spawned fish tend to be less susceptible to pathogens than hatchery-reared fish (Buchanon et al. 1983; Sanders et al. 1992). Habitat conditions such as low water flows and high temperatures can exacerbate susceptibility to infectious diseases. Fish weakened by disease are more sensitive to other environmental stresses, and may become more vulnerable to predation or less able to compete with other species.

Climate change. Climate change may adversely affect steelhead in freshwater habitats across the DPS by exacerbating existing problems with water quantity (lower summer stream flows) and water quality (higher summer water temperatures). These changes may affect steelhead more than other salmonids because of their long rearing period in

freshwater. More detailed information on specific effects that climate change may have on Mid-Columbia steelhead at all their life stages is available in Section 8.8 of the Oregon Steelhead Recovery Plan (ODFW 2009).

Limiting Factors and Threats for the MPGs

The MPG-level summaries of limiting factors are based on population-level summaries compiled from the relevant management unit plans.

Cascades Eastern Slope Tributaries MPG

The following are major limiting factors for the Cascades Eastern Slope Tributaries MPG (see also the Oregon Steelhead Recovery Plan [Appendix A] and the Klickitat Recovery Plan [Appendix B]):

Tributary habitat. Degraded tributary habitat is a limiting factor to a greater or lesser degree throughout the area, including degraded riparian areas, reduced recruitment of large woody debris (LWD), altered sediment routing, low or altered stream flows, degraded water quality (especially high water temperatures), impaired floodplain connectivity/function, altered channel structure/complexity, and impaired fish passage.

Mainstem passage. Mainstem Columbia River hydro system effects are least for the Fifteenmile Creek and Klickitat River populations, which pass only one mainstem dam. The Deschutes River populations pass two mainstem dams, and the Rock Creek population passes three. Effects, to varying degrees, include direct mortality of pre-smolts and smolts at the dams; delayed upstream migration of returning adults; and cumulative impact of hydropower system on mainstem and estuary habitat.

Hatchery related effects. Influence from hatchery fish could be a significant factor for this MPG because of out-of-subbasin hatchery fish straying onto natural spawning grounds in the Deschutes River and also because of potential effects of hatchery releases on naturally produced steelhead in the Klickitat River. The Oregon Mid-C Expert Panel considered out-of-subbasin (and out-of-DPS) hatchery strays a primary threat to genetic traits and productivity of naturally produced Deschutes river steelhead populations. Out-of-DPS hatchery strays comprised an estimated average of 29 percent of the Eastside population and 15.2 percent of the Westside population since 1990 (ICTRT 2008). This high fraction resulted in moderate risk ratings for spawner composition for both populations.

Blocked migration to historically accessible habitat. Historically, summer steelhead had free access to most of the Deschutes watershed. Currently the Pelton-Round Butte Hydroelectric Project (Project), constructed at river mile (RM) 100 on the mainstem Deschutes River, creates the primary barrier to anadromous fish attempting to reach spawning and rearing areas in the upper basin. Plans are underway to reinitiate fish passage facilities at the Pelton-Round Butte complex (details in Section 9.4.2 of the Oregon Steelhead Recovery Plan) and reintroduce steelhead to the upper basin, including the Crooked River.

Predation/competition/disease. Anthropogenic changes in the Columbia River have altered the relationships between salmonids and other fish, bird, and pinniped species. Predation, competition, and disease issues in mainstem and estuary affect all of the Middle Columbia steelhead populations (see Section 6.3.5 of this plan). In addition, the Oregon Steelhead Recovery Plan hypothesizes that the abundance of the Deschutes River Westside population may be limited by competition with a large resident population of rainbow trout.

John Day River MPG

The following are major limiting factors for the John Day River MPG (see also the Oregon Steelhead Recovery Plan [Appendix A]):

Mainstem passage. These populations must pass three dams; thus, limiting factors include direct mortality of pre-smolts and smolts at John Day, The Dalles, and Bonneville dams; delayed upstream migration of returning adults; false attraction of returning adults over McNary Dam; and cumulative impact of hydropower system on mainstem and estuary habitat.

Hatchery related effects. Hatchery fish straying into natural spawning areas pose risks to genetic traits and productivity of naturally produced steelhead. Concern over competition for resources with wild fish and potential hybridization with natural-origin fish resulted in termination of all hatchery stocking of *O. mykiss* in the John Day River basin in 1997. Most hatchery stray recoveries occur in the lower mainstem John Day River below the North Fork; however, strays have been observed in all populations.

Tributary habitat. For all five John Day populations, degraded floodplain and degraded channel structure, altered sediment routing, degraded water quality (temperature), and altered hydrology are limiting factors. For the Lower and Upper Mainstem and South Fork populations, passage obstructions in some of the smaller tributaries are also significant.

Predation/competition/disease. Predation, competition, and disease issues in mainstem and estuary affect all of the Middle Columbia steelhead populations.

Umatilla/Walla Walla MPG

The following are the major limiting factors for the Umatilla/Walla Walla MPG (see also the Oregon Steelhead Recovery Plan [Appendix A] and the Southeast Washington Plan [Appendix D]):

Mainstem passage. The Walla Walla and Touchet populations must pass four major dams; the Umatilla population must pass three. Thus, limiting factors include direct mortality of pre-smolts and smolts at John Day, The Dalles, and Bonneville dams; delayed upstream migration of returning adults; false attraction of returning adults over McNary Dam; and cumulative impact of hydropower system on mainstem and estuary habitat.

Tributary habitat. For all three populations, degraded water quality (temperature), altered sediment routing, blocked and impaired fish passage, degraded floodplain and channel structure and hydrologic alterations are limiting factors.

Hatchery related effects. The hatchery program on the Umatilla River uses endemic (native) stock and is not currently considered a threat to wild steelhead; however, out-of-DPS strays pose a risk to spawner composition. Non-endemic hatchery fish are considered a potential threat to the Walla Walla wild steelhead population. Currently, data are insufficient to determine whether hatchery effects are a problem for the Touchet River population. An endemic stock program is under development for the Walla Walla and Touchet.

Predation/competition/disease. Predation, competition, and disease issues in mainstem and estuary affect all of the Middle Columbia steelhead populations.

Yakima Basin MPG

The following are primary limiting factors for the Yakima MPG (see also the Yakima Steelhead Recovery Plan [Appendix E]):

Mainstem passage. As the farthest upstream populations in the DPS, the Yakima populations must pass four dams and undergo higher exposure to altered habitat and avian and piscine predators in the mainstem Columbia. Limiting factors include direct mortality of pre-smolts and smolts at John Day, The Dalles, and Bonneville dams; delayed upstream migration of returning adults; false attraction of returning adults over McNary Dam; and cumulative impact of hydropower system on mainstem and estuary habitat.

Tributary habitat. Fish habitat in the Yakima subbasin is substantially influenced by the development of irrigation systems. Limiting factors include altered hydrology (low summer flow because of withdrawals in tributaries and the lower Yakima, scouring peak flows because of degraded watershed conditions, high summer delivery flows in mainstem Yakima and Naches rivers, reduced winter and spring flows due to irrigation storage, delivery, and withdrawals); degraded riparian area and LWD recruitment; blocked and impaired fish passage (primarily due to storage and diversion dams, as well as entrainment in unscreened diversions); altered sediment routing; degraded water quality; loss of historical habitat because of blocked or impaired fish passage; degraded floodplain connectivity and function (loss of off-channel habitat, side channels and connected hyporheic zone); degraded channel structure and complexity; reduced outmigrant survival in the mainstem Yakima.

Hatchery related effects. The Yakima populations have the lowest rates of hatchery strays in the DPS, and hatchery effects are not considered a significant limiting factor.

Predation/competition/disease. Of the Middle Columbia steelhead populations, the Yakima basin populations have the longest migration through the mainstem Columbia

River. They may therefore be more vulnerable to some factors such as avian and piscivorous fish predation. For example, Yakima steelhead, but not the others, are consumed by Caspian tern and double-crested cormorants nesting on islands at the mouth of the Snake River.

DPS Recovery Strategy

NMFS' overall goal for DPS viability, as formulated by the ICTRT and described in Chapter 3 of this plan, is to have all four extant MPGs at viable (low risk) status, with representation of all the major life history strategies present historically, and with the abundance, productivity, spatial structure and diversity attributes required for long-term persistence.

The ICTRT's current status assessment for the Middle Columbia steelhead DPS and the gaps analysis show that for this DPS, the outlook is optimistic. One population, North Fork John Day, is currently at very low risk or "highly viable." Two populations are currently viable (Deschutes Eastside, Fifteenmile); eleven are at moderate risk, with good prospects for improving. However, the three large populations at high risk (Deschutes Westside, Naches, and Upper Yakima), are important to DPS viability; as a minimum, Deschutes Westside and one of the two large Yakima populations should also reach viable status, with the other large Yakima population at least reaching "maintained" status. These present significant, though not insuperable, challenges.

If, as we believe, the decline of the Middle Columbia River steelhead DPS is caused by widespread habitat degradation, impaired mainstem and tributary passage, hatchery effects, and predation/ competition/ disease, then actions taken to improve, change, mitigate, reduce those factors will result in reduced risks and increased survival. Because of the steelhead's complex life cycle and the many changes that have taken place in its environment, the factors limiting its survival must be addressed in concert, and in an integrated way. The work needs to occur at a regional level, in terms of commitment to actions and funding, and at the local level, population by population and site by site. Significant investments of research, planning, regional coordination, actions, and political will are already underway. The intent for the DPS plan is to build upon, help to coordinate, and add to the ongoing efforts.

NMFS' 2006 listing decision called upon Federal, state, and tribal entities to do their best to manage land, hydropower, hatchery, and harvest activities in a manner that would support steelhead recovery. This plan reaffirms those recommendations and adds to them the contributions of updated science, basinwide programs, and consensus building among stakeholders.

The recovery strategy for the Middle Columbia steelhead DPS addresses both the basin-wide issues that affect all populations, such as conditions in the migratory corridor, and the subbasin and site-specific issues that are the focus of the management unit plans. The DPS Plan describes the overall strategy, summarizes the MPG-level strategies, and refers to Appendices A-G for more site-specific, population level actions.

The DPS-level recovery strategy for the Middle Columbia steelhead is made up of the following elements:

- Affirm and address the 2006 listing decision recommendations to address the limiting factors for the DPS and populations.
- Protect and restore tributary habitat and Columbia River mainstem habitat, through strategies and actions at both the Basin/programmatic level and at the local level as detailed in the management unit plans.
- Address impaired fish passage through strategies and actions in the mainstem Columbia River, as detailed in the 2008 FCRPS Biological Opinion (as summarized in the Hydro Module) and in the tributaries as detailed in the management unit plans
- Implement hatchery reforms at the population and site specific level through Hatchery and Genetic Management Plans (HGMPs) as required by the 2008 FCRPS Biological Opinion and as described in Appendix C of the Supplemental Comprehensive Analysis, (NMFS 2008a).
- Address ecosystem imbalances in predation, competition, and disease through the strategies and actions in the management unit plans, estuary module and FCRPS Biop.
- Maintain current low harvest levels, through fishery management planning for mainstem fisheries through the *U.S. v. Ore*gon 10-year agreement, updated Fisheries Management Evaluation Plans and Tribal Resource Management Plans for tributary fisheries, and Pacific Salmon Treaty and Pacific Fishery Management Council processes.
- Protect and restore the estuary and Columbia River plume as detailed in the Columbia River Estuary module.
- Respond to climate change threats with a strategy based on the principle of preserving biodiversity.
- Implement the Plan through effective coordination and governance.
- Research critical uncertainties, monitor and evaluate implementation and effectiveness and adjust course, as appropriate through adaptive management.

NMFS believes that if this strategy is implemented and the biological response is as expected, the Middle Columbia steelhead DPS is likely to achieve viable status within 25 to 50 years.

Degraded tributary and mainstem Columbia River habitat
Measures to improve tributary habitat are contained in the management unit plans and are summarized above by MPG. Relatively little information is available concerning Middle Columbia River steelhead use of mainstem Columbia River habitat above Bonneville, aside from passage through the dams. NMFS believes it is important to assess nearshore habitat and cold water refugia in the mainstem and to explore opportunities for, and potential benefits from, restoration and protection of these areas.

Impaired fish passage in the mainstem Columbia River

Passage for juvenile steelhead migrating to the ocean and adult steelhead returning to their natal streams is limited primarily by the four Federal dams on the Lower Columbia River mainstem – Bonneville, John Day, The Dalles, and McNary dams – which are part of the Federal Columbia River Power System (FCRPS). NMFS recently issued a new biological opinion on the effects of FCRPS operations on salmonids, including Middle Columbia River steelhead, and on the predicted results of current and planned improvements to the system that are intended to improve fish survival (NMFS 2008a). These improvements are expected to increase the in-river survival of Middle Columbia River juvenile steelhead by 0.3 percent, 5.1 percent, 8.2 percent, and 10.2 percent, depending on the number of dams they must pass. The survival of steelhead adults through the four dams is thought to be relatively high at the present time (about 98.5 percent per project from Bonneville to McNary), and is expected to be maintained or improved.

The plan for current mainstem hydro operations, as summarized in the Hydro Module (NMFS 2008c), and any further improvements for fish survival that may result from the ongoing FCRPS collaborative process, represent the hydropower recovery strategy for all listed salmonids that migrate through the mainstem Columbia River, including the Middle Columbia steelhead populations.

The Reasonable and Prudent Alternative (RPA) for the FCRPS takes a comprehensive approach to ESA protection that includes hydro, habitat, hatchery, harvest and predation measures to address the biological needs of salmon and steelhead in every life stage. The RPA is the product of the collaboration between NMFS and the action agencies ordered by the court. It is based on a comprehensive analysis of the salmon life cycle conducted down to the level of the populations that make up the listed species. Section 8.8 and the "Reasonable and Prudent Alternative Table" in the 2008 FCRPS Biological Opinion describe actions that should positively affect Middle Columbia River steelhead.

The current plan for operation of the FCRPS through 2018 (NMFS 2008a) contains the following actions intended to address the needs for survival and recovery of ESA-listed salmon and steelhead:

- Continue adult fish passage operations that have resulted in improved survival.
- Improve juvenile fish passage: install removable spillway weirs or similar surface bypass devices at John Day and McNary dams, an extended tailrace spill wall at The Dalles Dam, and various modifications at Bonneville Dam. Passage for steelhead smolts at each of the four Lower Columbia River mainstem projects must reach 96 percent survival.
- Continue and enhance spill for juvenile fish passage.
- Continue reservoir operations and river flows to benefit spring migrating juveniles.
- Develop dry water year operations to better protect migrating juveniles.
- Develop and implement a kelt management plan.

Dissenting View of State of Oregon Regarding Mainstem Operations

At the time the proposed recovery plan was finalized, August 2008, it was the position of the State of Oregon that additional or alternative actions should be taken in mainstem operations of the FCRPS for ESA-listed salmon and steelhead. Some additional or alternative actions recommended by Oregon, while considered, were not included in NOAA's FCRPS Biological Opinion. At this time, Oregon is a plaintiff in litigation against various federal agencies, including NOAA, challenging the adequacy of the measures contained in the current FCRPS Biological Opinion. NOAA is not in agreement with Oregon regarding the need for or efficacy of Oregon's additional or alternative actions. The actions sought by Oregon include:

- Draft storage reservoirs to help meet weekly and seasonal flow and velocity equivalent objectives for the lower Columbia and Snake rivers.
- Operate reservoirs at rule curves and seek additional flow augmentation volumes from Snake River and Canadian reservoirs for spring and summer flow and velocity objectives.
- Operate John Day reservoir at minimum operating pool (MOP) during spring and summer as long as barge transport and irrigation needs are met.
- Provide spill to total dissolved gas limits of water quality waivers or biological constraints at all dams, except maximize transportation at Snake River collector projects during lowest (10^{th} percentile) flow years.
- Maintain approximately 50/50 in-river and transportation proportions for spring and summer migrants in the Snake River by optimizing spill and surface-oriented routes of dam passage and transporting fish collected in the turbine screen bypass systems. Continue to provide spill and bypass all fish at McNary Dam at all flows during the spring migration period.
- Test removable spillway weirs and temporary spillway weirs to ensure they provide equal or better benefits of full spill before reducing spill.
- Establish more rigorous research, monitoring and evaluation to assure that fish survival is increasing and to inform adaptive management.
- Identify and prepare contingency actions for implementation if necessary to meet fish performance standards linked to the survival and recovery requirements of listed fish.

Impaired fish passage in the tributaries

Actions to address fish passage in tributaries include:

- Implement locally developed management unit plans to improve fish passage in tributaries.
- Implement recovery plan recommendations regarding improved passage and flow management by the U.S. Bureau of Reclamation below all its facilities in the Yakima River and the Umatilla River subbasins, provision of fish passage into significant tributaries, and provision of passage over at least two of its storage dams in the Yakima Basin.[9]
- Implement recovery plan recommendations regarding improvement of fish passage, screening, and flow management in the Walla Walla River subbasin by

[9] The conservation measures in NOAA's 2006 listing decision specifically identify the need for passage at two or more of the storage dams in the Yakima Basin. The Yakima Steelhead Recovery Plan strongly recommends the provision of passage at the storage dams, but notes that the geographic distribution criteria detailed in the plan do provide for combinations of spawning areas that would meet de-listing and short-term recovery thresholds without provision of access above the storage dams (See Appendix E, Section 4.3.7).

the U.S. Army Corps of Engineers, and alteration of the flood operating rule for Mill Creek, or alternatively screening the diversion into Bennington Lake.
- Provide passage into the upper Deschutes River above Round Butte/Pelton complex and into the White Salmon River above Condit Dam.

Hatchery Reform

The hatchery programs in the Middle Columbia are managed under the Mitchell Act and the *U.S. v. Oregon* process, involving the fisheries co-managers and regulated by NMFS. NMFS is working with the funding agencies and hatchery operators to update and complete Hatchery and Genetic Management Plans (HGMPs) for every hatchery program in the Middle Columbia region as a means of organizing hatchery review and reform. The HGMPs are the basis for NMFS' biological opinions on hatchery programs under ESA sections 7 and 10 and the 4(d) rule, which relate to incidental and direct take of listed species. The HGMPs describe each hatchery's operations and the actions taken to support recovery and minimize ecological or genetic impacts, such as straying and other forms of competition with naturally produced fish.

Evaluating the factors that influence interactions between hatchery fish and naturally produced fish under varying freshwater conditions and ocean conditions is an important area of future research as well as ESA consultations and NEPA review. This is dealt with in more detail in Appendix C of the 2008 FCRPS Biological Opinion (NMFS 2008a) and in the final report of the HSRG.

The management unit plans propose various actions to reduce deleterious effects of hatcheries on natural production. For example, The Oregon Steelhead Recovery Plan proposes increased marking of Columbia Basin hatchery steelhead with coded-wire tags, and requiring mass marking of all hatchery steelhead releases with, at a minimum, an adipose fin-clip. Regional consensus has not been reached on these strategies, and the Mid-Columbia Forum will continue to pursue agreement on appropriate site-specific strategies. The Klickitat subbasin plan recommends a targeted monitoring program to determine abundance and productivity of natural spawners, determine the proportion of hatchery and wild spawners in the Klickitat subbasin, and determine the adverse effects of Skamania broodstock on the Klickitat population, if any. Further details are available in each management unit plan.

Predation, Competition and Disease

Predation, competition and disease are grouped together as a category of concern because ultimately these factors relate to balance and imbalance in the ecosystem. Improving habitat for salmonids throughout the life cycle is the best strategy for addressing these potential limiting factors (ISAB 2007). Specific measures can also be taken; these are summarized in Section 7.1.5.

The Plan addresses major avian, marine mammal and piscivorous fish predation issues in the mainstem Columbia River and tributaries and recommends immediate actions as well as research and monitoring to track trends in predator populations, understand their impacts on steelhead, and develop appropriate management techniques to reduce

predation. Competition of hatchery fish with naturally produced fish, for food, spawning areas, or other habitat resources, can be an issue at any life stage. The Plan recommends actions, research and monitoring in areas where competition may be a problem, particularly in the Klickitat, John Day, and Deschutes populations. Disease in salmonids is caused by multiple factors and probably cannot be directly addressed by recovery actions except in specific instances of known causal factors. It is more likely that nearly all of the recommended recovery actions that improve spawning, rearing, and passage conditions for steelhead and increase the survival, abundance, and productivity of naturally produced fish will result in decreasing incidence of disease.

Harvest
Although in general harvest is not considered a major threat for the Middle Columbia steelhead DPS, it is important to ensure that impacts from fisheries do not impede recovery, and to perform monitoring and evaluation to verify impacts and reduce existing uncertainties.

Columbia River Estuary and Plume
Because juvenile steelhead spend less residence time in the shallow parts of the estuary than other salmonids, the characteristics of the Columbia River plume and the deeper channels of the estuary are more important to their survival. NMFS' Estuary Module (NMFS 2007) identifies 23 types of management actions that would improve conditions in estuary and plume for all salmonids.

Climate Change
A strategy for addressing the effects of climate change on Middle Columbia River steelhead needs to be based, broadly, on the principle of preserving biodiversity. Diversity in terms of both location and biological characteristics gives any species resilience in the face of environmental change. This principle underlies the viability criteria presented in Chapter 3 of this plan, as well as the strategies described in this chapter to address the factors limiting steelhead viability, as these are currently understood. NMFS supports the ISAB's recommendations for mitigating the effects of climate change (ISAB 2007), most of which are encompassed in Chapter 7 of this Plan.

The ISAB notes that "As climate and streams warm, tributary habitats will become increasingly important because they usually provide the cool waters for salmonids and other cool-water species in a watershed" (ISAB 2007). It follows that water temperature and stream flow are factors that will remain important throughout steelhead freshwater habitat. All strategies and actions that help to lower water temperature or prevent further increase will help to mitigate climate change. Protecting and/or restoring riparian areas to increase shade, as recommended in Chapter 7 and the management unit plans, is an important strategy for minimizing water temperature increases. Additional actions include purchasing water rights to leave more water in streams and restoration actions to improve channel complexity and establish side-channel rearing (FCRPS BiOp, NMFS 2008a).

Recovery Strategies for the Four Major Population Groups

These summaries of recovery strategies for the four major population groups are drawn from the management unit plans and the ICTRT's status assessment (ICTRT 2008).

Cascades Eastern Slope Tributaries MPG

Population	Current Risk Status
Fifteenmile Creek (Oregon)	Viable
Deschutes Eastside (Oregon)	Viable
Klickitat (Washington)	(provisional) Moderate risk – insufficient data, hatchery influence
Rock Creek (Washington)	(provisional) High risk – insufficient data
Deschutes Westside (Oregon)	High risk
White Salmon (Washington)	Functionally extirpated
Crooked River (Oregon)	Extirpated

Primary limiting factors and threats (Section 6.4.1):

- Degraded tributary habitat
- Mainstem passage
- Hatchery related effects
- Blocked migration to historically accessible habitat
- Predation, competition, disease – in mainstem and estuary; possibly also in Deschutes Westside as competition with resident rainbow trout.

Recovery Scenario: For the Cascades Eastern Slope Tributaries MPG to be considered viable based on the currently extant populations, the Klickitat, Fifteenmile, and both the Deschutes Eastside and Westside populations should reach viable status, with one highly viable. The Rock Creek population should reach "maintained" status (25 percent or less risk level). MPG viability could be further bolstered if reintroduction of steelhead into the Crooked River succeeds and if the White Salmon population is successfully reintroduced to its historical habitat.

Gap: The median survival gap (assuming recent ocean and base hydrosystem conditions and 5 percent risk) for the Cascades Eastern Slope MPG is 0.21 (meaning that a 21 percent increase in average life-cycle survival is required to achieve 5 percent risk in a 100-year time period). The gap ranges from –0.34 (Deschutes Eastside) (no gap) to 0.78 (Deschutes Westside) (needs 78 percent improvement). There was not enough information to estimate gaps for the Klickitat or Rock Creek populations.

Key actions proposed (Section 7.2.1):

- Protect, improve, and increase freshwater habitat for steelhead production. Improvements to freshwater habitat should be targeted to address specific limiting factors in specific areas as described in the Oregon Steelhead Recovery Plan and the Washington Gorge plans.

- Reduce straying of out-of-DPS hatchery fish onto natural spawning grounds within the Deschutes subbasin.
- Restore historical passage to the upper Deschutes subbasin including the Westside tributaries and Crooked River above Pelton Round Butte dam complex and the White Salmon River above Condit Dam.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007 and Appendix G of this Plan) and FCRPS Biological Opinion (NMFS 2008a) (as summarized in the Hydro Module (NMFS 2008c and Appendix F of this Plan).
- Improve hatchery management to minimize impacts from hatchery releases on naturally produced steelhead within the Deschutes West and East and Klickitat subbasins.
- Fill data gaps for better assessment of Klickitat and Rock Creek steelhead populations.
- Coordinate between scientists, planners, and implementers of recovery actions on both sides of the Columbia River for sequencing of recovery actions and monitoring for adaptive management.

John Day River MPG

Population	**Current Risk Status**
North Fork John Day	Highly viable
Upper Mainstem John Day	Moderate risk
Lower Mainstem John Day	Moderate risk
Middle Fork John Day	Moderate risk
South Fork John Day	Moderate risk

Main limiting factors and threats (Section 6.4.2):

- Degraded tributary habitat
- Mainstem passage
- Hatchery related effects
- Predation/competition/disease in mainstem and estuary

Recovery Scenario: For the John Day River MPG to reach viable status, the Lower Mainstem John Day River, North Fork John Day River, and either the Middle Fork John Day River or Upper Mainstem John Day River populations should achieve viable status, with one highly viable.

Gap: The median survival gap for the John Day MPG is 0.09, ranging from –0.49 (North Fork) (no gap) to 0.34 (South Fork) (needs 34 percent improvement in average survival over the life cycle).

Key Actions proposed (7.3.2):

- Protect and improve freshwater habitat conditions and connectivity for steelhead production. Improvements to freshwater habitat should be targeted to address specific factors in specific areas as described in the Oregon Steelhead Recovery Plan.

- Improve hatchery management to reduce straying from out-of-DPS hatchery fish onto natural spawning grounds within the John Day subbasin.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007 and Appendix G of this Plan) and FCRPS Biological Opinion (NMFS 2008a)

Umatilla/Walla Walla MPG

Population	Current Risk Status
Umatilla River	Moderate Risk
Walla Walla River	Moderate Risk
Touchet River	High Risk (provisional because of insufficient data)

Main limiting factors and threats (Section 6.4.3):

- Mainstem passage (Touchet and Walla Walla populations pass four major dams: the Umatilla population must pass three.)
- Tributary habitat
- Hatchery related effects
- Predation/competition/disease

Recovery Scenario: For the Umatilla/Walla Walla MPG to be viable, two populations should meet viability criteria, and one should be highly viable. The Umatilla River population is the only large population, and therefore should be viable. Either the Walla Walla River or Touchet River population also should be viable.

Gap: There was sufficient information available to estimate gaps for only two of the three populations within the Umatilla/Walla Walla MPG. Assuming base hydrosystem and recent ocean conditions, the survival gaps for the Umatilla and Walla Walla populations are 0.09 and 0.34, respectively.

Key actions proposed (Section 7.2.3):

- Coordinate between planners, scientists and those implementing recovery actions in Washington and Oregon for sequencing, monitoring, and adaptive management.
- Protect and improve freshwater habitat conditions and access for steelhead production. Improvements to freshwater habitat should be targeted to address specific factors in specific areas as described in the Southeast Washington Plan and the Oregon Steelhead Recovery Plan.
- Improve hatchery management to reduce straying by out-of-DPS hatchery fish onto natural spawning grounds within the Umatilla/Walla Walla subbasins.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007 and Appendix G of this Plan) and FCRPS Biological Opinion (NMFS 2008a) (as summarized in the Hydro Module, NMFS 2008c and Appendix F of this Plan).

Yakima River MPG

Population	Current Risk Status
Upper Yakima River	High Risk
Naches River	High Risk
Satus Creek	Moderate Risk
Toppenish Creek	Moderate Risk

Main limiting factors and threats (Section 6.4.4):

- Tributary habitat: Influence of major irrigation system development. Altered hydrology; degraded habitat; loss of habitat; impaired fish passage; reduced outmigrant survival in Yakima mainstem.
- Mainstem passage (four dams).

Status: The Yakima MPG is currently rated at High Risk. The two largest populations in the drainage (Naches and Upper Yakima) are rated at High Risk; the Satus Creek and Toppenish Creek populations are rated as Maintained.

Recovery Scenario: For the Yakima River MPG to achieve viable status, two populations should be rated as viable, including at least one of the two classified as Large – either the Naches River or the Upper Yakima River. The remaining two populations should, at a minimum, meet the Maintained criteria.

Gap: The median survival gap (assuming recent ocean and base hydrosystem conditions) for the Yakima MPG is 0.77 (needs 77 percent improvement in average survival over the life cycle), ranging from 0.22 (Satus—tributary only) to 1.15 (Upper Yakima). This is the highest median survival gap of the four MPGs in the Middle Columbia steelhead DPS.

Key actions proposed (Section 7.2.4):

- Protect and enhance habitat in key tributary watersheds in the Yakima Basin.
- Restore passage to blocked areas in the Naches and Upper Yakima population areas.
- Alter irrigation delivery and storage operations in the Yakima Basin to improve flow conditions for Middle Columbia steelhead and use managed high flows to maintain floodplain habitat.
- Improve channel and floodplain function and reduce predation through the mainstem Yakima and Naches Rivers.
    - Improve survival in the mainstem Columbia and its estuary through actions detailed in NMFS Estuary Module (NMFS 2007 and Appendix G of this Plan) and FCRPS Biological Opinion (NMFS 2008a) (as summarized in the Hydro Module, NMFS 2008c and Appendix F of this Plan).

Time Required and Cost Estimates

Estimating time and cost for salmon and steelhead recovery, given the complex relationship of these fish to the environment and to human activities on land, poses unique challenges. NMFS estimates that recovery of the Middle Columbia steelhead DPS could take 25 to 50 years. The management unit plans (Appendices A through E) contain extensive lists of actions to recover the Middle Columbia steelhead DPS populations. These projects were developed using the most up-to-date assessment of Middle Columbia steelhead recovery needs. The management unit plans focus, for the most part, on actions ranging from 5 to 15 years. There are many uncertainties involved in predicting the course of recovery and in estimating total costs. Such uncertainties include biological and ecosystem responses to recovery actions as well as long-term and future funding.

Cost Estimates

Cost estimates for recovery projects were provided by the management unit entities where available information was sufficient to do so, using the methods described in each management unit plan. No cost estimates are provided for (1) baseline actions (programs that are already in existence), which are listed as Not Applicable (N/A); or (2) actions for which costs, unit costs, or project-scale estimates are yet to be developed. These are listed as To Be Determined. Cost figures will be updated as improved information becomes available.

The total estimated cost of restoring habitat for the Middle Columbia steelhead DPS is approximately $235 million over the initial 5-year period, and approximately $996 million over 20 to 50 years for all DPS-wide recovery actions for which sufficient information exists upon which to base an estimate (Table ES-4). However, they do not include costs associated with implementing actions within the lower Columbia River, estuary or Federal Columbia River Power System (FCRPS).

This estimate includes expenditures by local, tribal, state, and Federal governments, private business, and individuals, in implementing both capital projects and non-capital work. Administrative costs are embedded in the total management unit cost estimates in Table ES-4. Preliminary research, monitoring and evaluation costs have, in some cases, been estimated at the management unit level; however, these costs are not included at this time pending completion of research and monitoring plans and further development of each project.

Table ES-4 Summary of Cost Estimates for Habitat Projects for Middle Columbia Steelhead DPS.

Recovery Plan	First 5 Years ($M)	Project/Program Total ($M)
Oregon	$ 103.5	$ 512.8
Yakima Steelhead[10]	$ 91.9	$ 269.3
SE Washington[11]	$ 25.5	$ 76.4
Klickitat[12],[13]	$ 12.9	$ 129.4
Rock Creek[14]	$ 0.9	$ 1.8
White Salmon Steelhead	N/A	$ 6.5
DPS Totals	**$ 234.7**	**$ 996.2**

These cost estimates do not include expenses associated with implementing actions within the lower Columbia River, estuary, or Federal Columbia River Power System (FCRPS), first, because of the basin-wide scope and applicability of these actions to all 13 Columbia Basin salmonid species listed as threatened or endangered, and second, because they are considered "baseline actions" that are required through other processes such as section 7 consultations, FERC licensing agreements, and Habitat Conservation Plans. Cost estimates for estuary actions are included in a module that is incorporated into the Plan as Appendix G, and is available on the NMFS website: www.nwr.noaa.gov/Salmon Recovery Planning/ESA Recovery Plans/Other Documents.cfm. The estuary recovery costs could be further refined following public comment on the module and on the ESA recovery plan for the three listed lower Columbia River ESUs and one listed lower Columbia River steelhead DPS in 2009. Costs for hatchery actions required through other processes such as consultations, permits, and 4(d) Rule implementation are not part of recovery costs reported here because the programs are already in existence or are undergoing required modifications. There are few estimated costs for recovery actions associated with harvest to report at this time. This is because no actions are currently proposed that go beyond those already being implemented through *U.S. v. Oregon* and other harvest management forums. In the event that additional harvest actions are implemented through these forums, those costs will be

[10] The Yakima steelhead plan estimates costs for the first 6 years, and includes preliminary RME cost estimate of $300K/year. The 5-year estimate is extrapolated from the 6-year cost data .
[11] The SE Washington plan estimates annual steelhead implementation costs at about $5 million per year. The 5-year estimate is extrapolated by multiplying the annual amount by five.
[12] The Klickitat plan estimates costs for the first 10 years. Five-year estimate extrapolated by dividing the 10-year amount in half.
[13] The Klickitat plan uses a 50-year period to estimate its total project costs.
[14] The Rock Creek plan estimates cost for first 3 years and 10 years. The 5-year estimate is extrapolated from the 3-year value.

added during the implementation phase of this recovery plan. All cost estimates will be refined and updated over time.

Cost estimates from the draft cost chapters in the individual management plans were developed as consistently as possible, in that they all applied guidance provided by NMFS. However, the approaches vary to some degree given the local and independent nature of the planning groups. Costs developed in the management unit plans were estimated using several basic assumptions (i.e., neither baseline costs nor out-of-basin costs were included in the estimates) and used similar cost calculation methodologies. There are, however, differences in the timeframes for cost estimates.

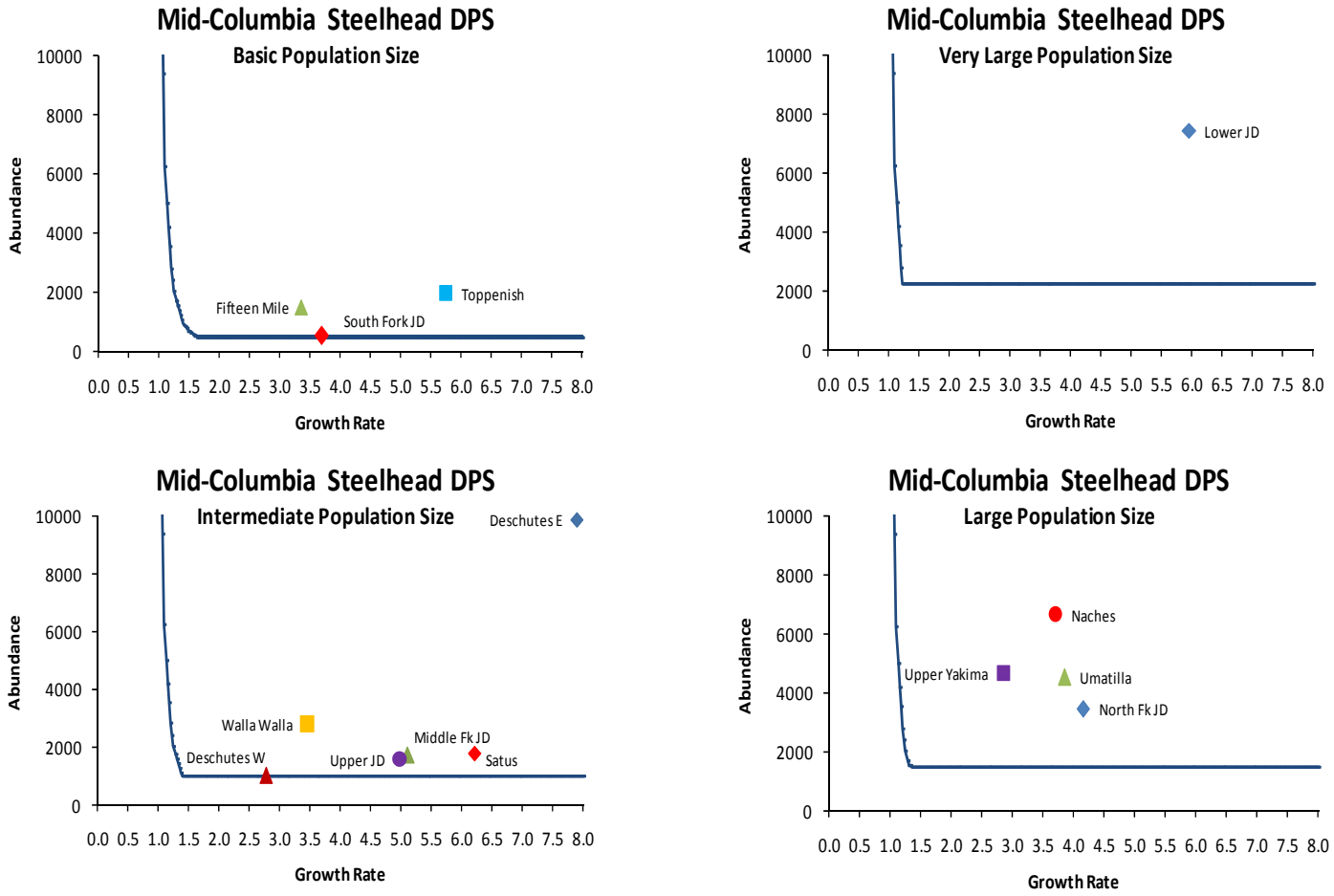
Potential Effects of Proposed Recovery Actions

Chapter 9 in this plan presents an analysis of the potential effects of implementing all the proposed recovery actions – in all the "H" sectors – on the abundance and productivity of Middle Columbia River steelhead. This quantitative analysis provides an opportunity to evaluate the efficacy of proposed recovery strategies in light of current knowledge regarding population functioning, including relationships with habitat conditions. Equally important, the quantitative models used in the assessment provide a framework for productively targeting evaluation efforts as well as for revisiting key assumptions in the future as more information becomes available (e.g., from monitoring responses to initial implementation or from evaluation efforts targeting key uncertainties). Two models were used: Ecosystem Diagnosis and Treatment (EDT) and the All-H-Analyzer (AHA). Methods of analysis are explained in detail in Chapter 9 of this Plan.

The analysis indicates, based on the suites of proposed actions in all the sectors, that all Middle Columbia River steelhead populations for which there are adequate data are expected to achieve 95 percent probability of survival (less than 5 percent risk of extinction within 100 years) for abundance/productivity if the most intensive (major) restoration scenarios are implemented and the projected habitat changes are realized after 25 years of implementation. Under minimum restoration scenarios, three populations (Deschutes Westside, Satus, and Upper Yakima) may not achieve less than 5 percent risk for abundance/productivity. However, the Satus population would meet the recovery criteria identified in the Yakima Steelhead Recovery Plan, and even under poor ocean conditions and minimum restoration actions, the abundance and productivity of the other two populations are expected to increase considerably over the baseline.

Figure ES-6 shows the projected (modeled) abundance and productivity of the 14 populations for which there are adequate data (excluding the Rock Creek, Klickitat, and Touchet populations) after 25 years and major restoration actions. The curve represents the abundance and productivity needed to achieve 95 percent probability of survival for the next 100 years.

Figure ES-6. Predicted viability results for Middle Columbia Steelhead Populations after 25 years of major restoration efforts.



Research, Monitoring, and Evaluation

An important part of the strategy for achieving recovery is the development of a DPS-wide monitoring plan that will support implementation of the recovery plan and long-term adaptive management in response to changes and trends in the data. Two keys to effective implementation are targeting actions to specific areas and monitoring the results of the actions. To achieve these goals, a scientific technical team made up of local scientists, former ICTRT members, and managers will be necessary. The monitoring plan is discussed in more detail in Chapter 10. It is also important to explicitly address the many unknowns in salmon recovery – the "critical uncertainties" that make management decisions much harder. Critical uncertainty research will, in the long run, reduce monitoring and implementation costs. Critical uncertainties and data gaps are described in more detail in Sections 10.3 and 10.4.

Adaptive Management

Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions. Adaptive management works by coupling the decision-making process with collection of performance data and its evaluation. Most importantly, it works by offering an explicit process through which alternative strategies to achieve the same ends can be considered.

Within the Middle Columbia Basin, many different organizations, including Federal, state, tribal, local, and private entities, currently conduct programs and actions that could improve Middle Columbia steelhead survival. Development of Middle Columbia regional coordination will be essential for NMFS' future status reviews of the steelhead DPS. Establishing stable funding and staff for reporting data is also important. Management unit planners are developing detailed research, monitoring, evaluation, and adaptive management plans for each management unit based on the principles and concepts laid out in the NMFS draft guidance document, Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance (http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf). The individual RM&E and adaptive management plans will then be combined into a DPS RM&E and adaptive management plan by the Middle Columbia Science Team. This will ensure that, taken together, the monitoring and evaluation programs for each management unit, combined with monitoring components of the modules incorporated into the plans, address the needs of the entire DPS. The Mid-C Forum and others will use the RM&E and adaptive management plans to inform and guide projects and programs.

Setting Priorities

Priorities for recovery actions should be guided by DPS-, MPG-, and population-level recovery criteria and best available scientific information concerning DPS status, the role of the independent populations in meeting DPS and MPG viability, limiting factors and threats, and likelihood of effectiveness of actions. Protection of existing habitat is essential. Issues of funding and local, state, or national support for implementation will also inevitably come into play.

The management unit plans all address these issues in their implementation sections. For recovery actions in the tributaries, priorities will be settled largely at the local level. However, there should be ongoing technical review and support from DPS-level and management unit

science and technical committees. Coordination and communication in "out-of-subbasin" forums will be necessary for actions in the Columbia mainstem, estuary, and/or ocean.

Coordination/Governance

Coordination of actions and information-sharing among fisheries biologists, Tribes, local governments, citizen groups, and state and Federal agencies based in both Oregon and Washington is a key component of recovery for this DPS. Benefits of coordination include:

- Dealing with shared migration areas consistently
- Developing coherent MPG-level strategies where populations are in two states (Cascades Eastern Slope MPG; Umatilla/Walla Walla MPG), or the same population is in both states (Walla Walla population)
- Promoting consistent methods for setting recovery objectives, evaluating strategies, and monitoring progress across populations, MPGs, and the DPS

Such coordination is underway through the Middle Columbia Recovery Forum (Mid-C Forum), a group convened by NMFS to provide input on the DPS recovery plan.

Middle Columbia Recovery Forum

The recent creation of the Middle Columbia Recovery Forum (Mid-C Forum), to be convened regularly by NMFS, is intended to facilitate collaboration between scientists and recovery planners on both sides of the Columbia River. Figure ES-7 gives an overview of the relationships between these entities. Chapter 11 of this plan describes in more detail the proposed roles and responsibilities.

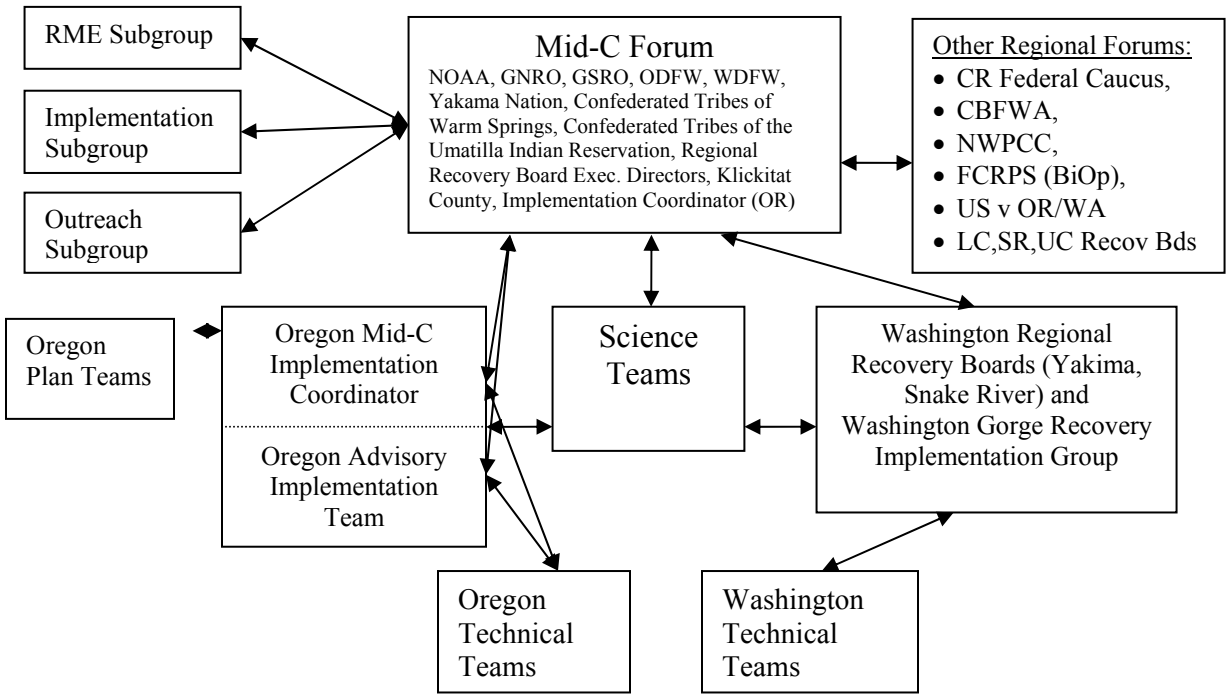


Figure ES-7. Mid-C Recovery Plan Implementation Organizational Structure.

Implementation Funding

Funding for project implementation is currently available from a variety of sources, but it will be an ongoing challenge. The role of the Mid-C Forum is to ensure that management unit plan implementers are aware of potential sources of funds and to advocate for the funding and implementation of actions that benefit all populations in the DPS. The Forum will not supersede decisions made by the individual management unit boards but will provide assistance and may promote funding of their projects and programs if requested. Sources of implementation funding include:

- Congressional appropriations to Federal agencies and to Pacific Coastal Salmon Recovery Fund (PCSRF) (through states and tribes)
- Salmon Recovery Funding Board (SRFB) (Washington)
- Oregon Watershed Enhancement Board (OWEB) (Oregon)
- State appropriations (state agencies)
- Northwest Power and Conservation Council Fish and Wildlife Program (states and tribes)
- Federal/state grants
- Non-profit organization programs and grants

How NMFS Intends to Use the Plan

Although recovery plans are not regulatory and their implementation is voluntary, they are important tools that help to do the following:

- Provide context for regulatory decisions.
- Guide decision making by Federal, state, Tribal, and local jurisdictions.
- Provide criteria for status reporting and delisting decisions.
- Organize, prioritize, and sequence recovery actions.
- Organize research, monitoring, and evaluation efforts.

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions carried out to meet section 7(a)(1) obligations to use their programs in furtherance of the purposes of the ESA and to carry out programs for the conservation of threatened and endangered species
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10
- Hatchery and Genetic Management Plans and permit requests
- Harvest plans and permits
- Selection and prioritization of subbasin planning actions
- Development of research, monitoring, and evaluation programs
- Revision of land use and resource management plans
- Other natural resource decisions at the state, Tribal, and local levels

NMFS will emphasize recovery plan information in ESA section 7(a)(2) consultations, section 10 permit development, and application of the section 4(d) rule by considering:

- The importance of affected populations to listed species viability
- The importance of the action area to affected populations and species viability
- The relation of the action to recovery strategies and management actions
- The relation of the action to the research, monitoring, and evaluation plan for the affected species

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. NMFS staff will encourage the Federal action agencies to describe in their biological assessments how, within the action area, their proposed actions will affect individuals of specific populations and limiting factors identified in the recovery plans, and to describe any mitigating measures and voluntary recovery activities in the action area.

Middle Columbia River Steelhead ESA Recovery Plan

1. INTRODUCTION

This is a recovery plan (Plan) for the protection and restoration of Middle Columbia River steelhead (*Oncorhynchus mykiss*), which spawn and rear in tributaries to the Columbia River in central and eastern Washington and Oregon (Figure 1-1). The Middle Columbia River steelhead distinct population segment (DPS) was listed as threatened under the Endangered Species Act of 1973 (ESA) on January 5, 2006 (71 FR 834).

NOAA's National Marine Fisheries Service (NMFS) is required, pursuant to Section 4(f) of the Endangered Species Act (ESA) of 1973, to develop recovery plans for marine species listed under the Act. Recovery plans identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA.

Nineteen of the 33 salmon and steelhead species in the Northwest region are listed as threatened or endangered. The Middle Columbia steelhead is among those with the best prospects of recovery, although it will require considerable political will and investment of long-term effort and funding. Modeling of the potential effects of the actions that are proposed in this plan (see Chapter 9) predicts that the DPS can achieve a "negligible" risk of extinction within a reasonable time frame – e.g. 25 to 50 years – if the actions are taken and if they have the predicted effects on steelhead habitat and survival. Cautious though this statement may be, it is a beacon of hope in the complex realm of salmonid recovery in the Northwest.

A recovery plan serves as a road map for species recovery—it lays out where we need to go and how best to get there. Without a plan to organize, coordinate and prioritize the many possible recovery actions on the part of Federal, state, and tribal agencies, local watershed councils and districts, and private citizens, our efforts may be inefficient or even ineffective. Prompt development and implementation of a recovery plan will help target limited resources effectively. Although recovery plans are guidance, not regulatory documents, the ESA clearly envisions recovery plans as the central organizing tool for guiding each species' recovery process.

Over the course of their life cycle, Middle Columbia River steelhead use habitats across a wide geographic range. They spawn and rear in the upper and middle reaches of freshwater tributaries, then migrate as juveniles through the lower tributary reaches and the mainstem Columbia River to the estuary and ocean. After one to five years in the ocean, the adults migrate upstream to their natal streams. The long-term biological success of steelhead is based on their ability to make use of these diverse habitats. Their resilience in the face of change depends on maintaining genetic, phenotypic, and behavioral diversity over a wide geographic area.

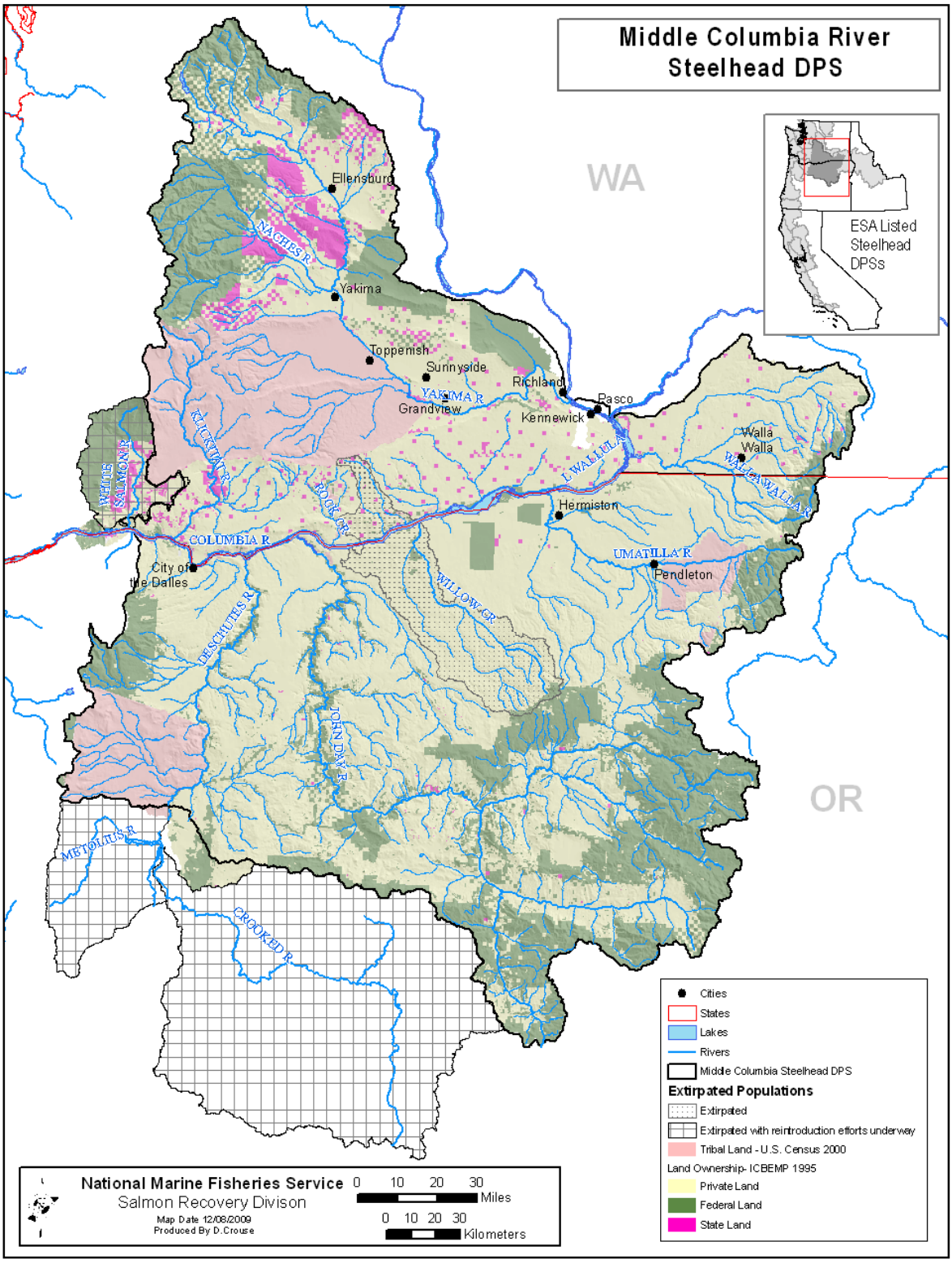


Figure 1-1. Geographic boundaries of the Middle Columbia River Steelhead DPS, showing land ownership.

Human activities have dramatically changed this geography. Although many of the deleterious effects on fish habitat are due to past practices, current human uses of the land and river systems continue to affect steelhead habitat and viability across much of its Middle Columbia range. A growing number of people now recognize the opportunities and benefits of actively protecting and restoring stream corridors, wetlands, stream flows, and other natural features that support native fish and wildlife populations. Management of upland areas is changing to protect or restore watershed function, and cities are undertaking urban watershed protection and restoration. Recovery planning is an opportunity to search for the common ground among affected parties, to organize protection and restoration of salmonid habitat, and to secure the economic and cultural benefits that accrue to human communities from healthy watersheds and rivers. While Federal, state, and tribal entities can make major contributions to the recovery of Middle Columbia steelhead, the actions of individuals on their land, as well as city and county codes and ordinances promoting conservation, are also essential.

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act and can be delisted. Recovery plans may also contain "broad sense goals" that go beyond the requirements for delisting to address other legislative mandates or social, economic, and ecological values. The various locally produced plans contain broad sense goals adopted by local planning entities. These broad sense goals, while stated in slightly different ways, usually share some combination of the following elements: ensuring long-term persistence of viable populations of naturally produced steelhead distributed across their native range; enjoying the social and cultural benefits of meaningful harvest opportunities that are sustainable over the long term; and pursuing salmon recovery using an open and cooperative process that respects local customs and benefits local communities and economies. Recovery goals and delisting criteria are discussed in greater detail in Chapter 3.

1.1 ESA Requirements

Section 4(f) of the ESA requires that a recovery plan be developed and implemented for species listed as endangered or threatened under the statute.

ESA section 4(a)(1) lists factors for re-classification or delisting that are to be addressed in recovery plans:

A. The present or threatened destruction, modification, or curtailment of [the species'] habitat or range
B. Over-utilization for commercial, recreational, scientific or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting its continued existence

ESA section 4(f)(1)(B) directs that recovery plans, to the extent practicable, incorporate:

1. a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
2. objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this chapter, that the species be removed from the list; and;

3. estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In addition, it is important for recovery plans to provide the public and decision makers with a clear understanding of the goals and strategies needed to recover a listed species and the science underlying those conclusions (NMFS 2006).

Once a species is deemed recovered and therefore removed from a listed status, section 4(g) of the ESA requires the monitoring of the species for a period of not less than five years to ensure that it retains its recovered status.

1.2 How NMFS Intends to Use the Plan

Although recovery plans are not regulatory and their implementation is voluntary, they are important tools that help to do the following:

- Provide context for regulatory decisions.
- Guide decision making by Federal, state, Tribal, and local jurisdictions.
- Provide criteria for status reporting and delisting decisions.
- Organize, prioritize, and sequence recovery actions.
- Organize research, monitoring, and evaluation efforts.

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions carried out to meet section 7(a)(1) obligations to use their programs in furtherance of the purposes of the ESA and to carry out programs for the conservation of threatened and endangered species
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10
- Hatchery and Genetic Management Plans and permit requests
- Harvest plans and permits
- Selection and prioritization of subbasin planning actions
- Development of research, monitoring, and evaluation programs
- Revision of land use and resource management plans
- Other natural resource decisions at the state, Tribal, and local levels

NMFS will emphasize recovery plan information in ESA section 7(a)(2) consultations, section 10 permit development, and application of the section 4(d) rule by considering:

- The importance of affected populations to listed species viability
- The importance of the action area to affected populations and species viability
- The relation of the action to recovery strategies and management actions
- The relation of the action to the research, monitoring, and evaluation plan for the affected species

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. NMFS staff will encourage the Federal "action agencies" to describe in their biological assessments how, within the action area, their proposed actions will

affect individuals of specific populations and limiting factors identified in the recovery plans, and to describe any mitigating measures and voluntary recovery activities in the action area.

1.3 Middle Columbia Steelhead DPS Geographic Setting

The range of the Middle Columbia steelhead DPS extends over approximately 35,000 square miles in the Columbia plateau of eastern Washington and eastern Oregon. The DPS includes all naturally spawned populations of steelhead in drainages upstream of the Wind River, Washington, and the Hood River, Oregon (exclusive), up to, and including, the Yakima River, Washington, but excluding steelhead from the Snake River Basin (64 FR 14517; 71 FR 849). Major drainages in this DPS are the Deschutes, John Day, Umatilla, Walla Walla, Yakima, and Klickitat river systems. The Cascade Mountains form the western border of the plateau in both Oregon and Washington, while the Blue Mountains form the eastern edge. The southern border is marked by the divides that separate the upper Deschutes and John Day basins from the Oregon high desert and drainages to the south. The Wenatchee Mountains and Palouse areas of eastern Washington border the Middle Columbia on the north.

Temperatures and precipitation vary widely, usually depending on elevation, with cooler and wetter climates in the mountainous areas at the western and eastern boundaries and warmer and drier climates in the lower portions of the watersheds that make up most of the province. The mountainous regions are predominately coniferous forests, while the arid regions are characterized by sagebrush steppe and grassland.

Most of the region is privately owned (64 percent), with the remaining area under Federal (23 percent), tribal (10 percent) and state (3 percent) ownership (Figure 1-1). The landscape, throughout the range of this DPS, is heavily modified for human use, even where populations are low. Most of the landscape consists of are rangeland and timberland, with significant concentrations of dryland agriculture in parts of the range. Irrigated agriculture and urban development are generally concentrated in valley bottoms. Populations in these regions are growing.

1.4 Relationship of Steelhead DPS to Resident *O. mykiss*

"Steelhead" is the name commonly applied to the anadromous (migratory) form of the biological species *Oncorhynchus mykiss*. The common names of the non-anadromous, or resident, form are rainbow trout and redband trout. When NMFS originally listed the Middle Columbia River steelhead as threatened on March 25, 1999 (64 FR 14517), it was classified as an "evolutionarily significant unit" (ESU) of salmonids that included both the anadromous and resident forms. Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS). NMFS listed the Middle Columbia River steelhead DPS as threatened on January 5, 2006 (71 FR 834). Rainbow trout and redband trout are under the jurisdiction of the states unless they are listed, when they come under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). This recovery plan addresses steelhead and not rainbow trout, as is consistent with the 2006 ESA listing decision.

NMFS based its DPS determination on the fact that "despite the apparent reproductive exchange between resident and anadromous *O. mykiss*, the two life forms remain 'markedly separated' as a consequence of physical, physiological, ecological, and behavioral factors. . . . Steelhead differ

from resident rainbow trout physically in adult size and fecundity, physiologically by undergoing smoltification, ecologically in their preferred prey and principal predators, and behaviorally in their migratory strategy." (71 FR 838).

NMFS acknowledges that the data necessary to evaluate the current status and trends of resident populations are generally lacking, as well as historical data necessary to evaluate trends in abundance and distribution of the two life history forms. NMFS concluded that the collective contribution of the resident life history form to persistence of steelhead is unknown, and may not substantially reduce the overall extinction risk of the steelhead DPS (71 FR 834). Individual management unit plans may identify research and monitoring needs to better understand the status and trends of resident rainbow trout in order to address these data gaps.

1.5 Context of Plan Development

This plan is the product of a collaborative process initiated by NMFS that involves the State of Washington, regional salmon recovery organizations within Washington, the State of Oregon (led by the Oregon Department of Fish and Wildlife, with support from a collaborative sounding board), emerging regional sounding boards within Oregon, other Federal agencies, state agencies, Tribes, local governments, and the public.

While NMFS is directly responsible for ESA recovery planning for salmon and steelhead, NMFS believes that ESA recovery plans for salmon and steelhead should be based on the many state, regional, tribal, local, and private conservation efforts already underway throughout the region. Local support of recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential. NMFS therefore supports and participates in locally led collaborative efforts to develop recovery plans that involve local communities, state, tribal, and Federal entities, and other stakeholders.

NMFS developed the Middle Columbia Steelhead DPS ESA Recovery Plan with assistance from the Middle Columbia Recovery Forum (Mid-C Forum), a group convened by NMFS to provide input on the DPS recovery plan. NMFS developed this Plan by drawing upon the best available scientific information provided by the four regional recovery plans included as appendices to this Plan (i.e. the management unit plans, described below and in Section 1.6.), and by a regional team of scientists (the Interior Columbia Technical Recovery Team, described below). The draft plan went through repeated reviews and revisions in response to comments from both the scientific team and the Mid-C Forum. Participants in the Mid-C Forum include the Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), the Yakama Nation, Confederated Tribes of the Warm Springs Indian Reservation, Confederated Tribes of the Umatilla Indian Reservation, Washington Governor's Salmon Recovery Office, Oregon Governor's Natural Resources Office, Snake River Salmon Recovery Board, Yakima Basin Fish and Wildlife Recovery Board, US Bureau of Reclamation (BOR), US Fish and Wildlife Service (USFWS), US Forest Service (USFS), US Army Corps of Engineers (COE), Klickitat County, and NMFS Northwest Region.

The Draft Recovery Plan, including the four management unit plans and two scientific reports (McClure et al. 2003; ICTRT 2007a) that provide the scientific basis for the Plan, was made available for public review as a Proposed Recovery Plan. NMFS revised the Proposed Plan in

response to public comments, including comments from the ICTRT as peer reviewers. The responses to public comments are available on the NMFS website, at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Interior-Columbia/Mid-Columbia/upload/Mid-C-response.pdf

1.5.1 Recovery Domains and Technical Recovery Teams

Currently, there are 19 ESA-listed ESUs/DPSs of Pacific salmon and steelhead in the Pacific Northwest. NMFS Northwest Region also shares jurisdiction of an additional ESU, Southern Oregon/Northern California coho, with NMFS Southwest Region. For the purpose of recovery planning for these species, NMFS Northwest Region designated five geographically based "recovery domains": Interior Columbia; Willamette-Lower Columbia; Puget Sound and Washington Coast; the Oregon Coast; and the Southern Oregon/Northern California Coast (Figure 1-2). The range of the Middle Columbia River steelhead DPS is located in the Middle Columbia sub-domain of the Interior Columbia domain (the other Interior Columbia sub-domains are the Snake River and Upper Columbia).

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each Technical Recovery Team (TRT) is to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. The Interior Columbia TRT (ICTRT) included biologists from NMFS, states, tribes, and academic institutions.

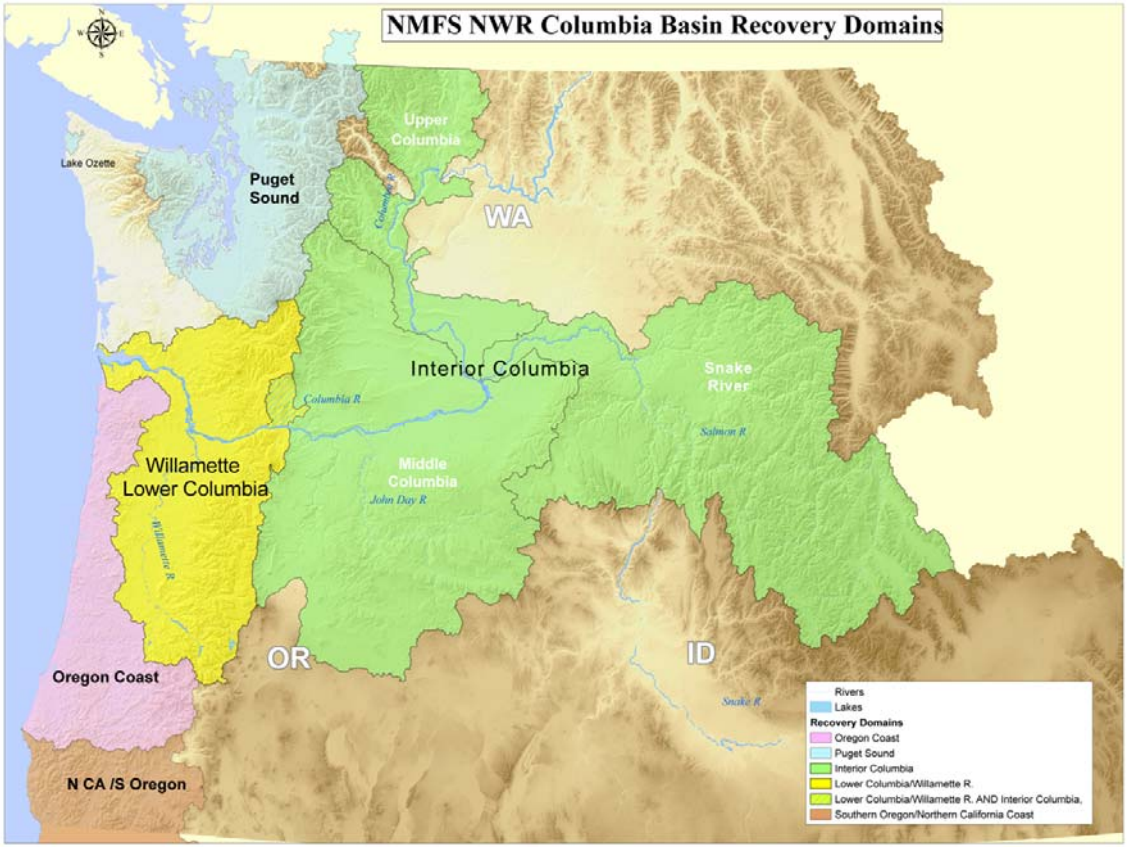


Figure 1-2. Columbia Basin Recovery Domains for NMFS Northwest Region.

All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population viability criteria – criteria to be used, along with criteria based on mitigation of the factors for decline, to determine whether a species has recovered sufficiently to be downlisted or delisted. These principles are described in a NMFS technical memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). Viable salmonid populations (VSP) are defined in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework, based on data availability, the unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective experience and expertise. Although NMFS encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs worked from a common scientific foundation.

1.5.2 Management Units

In each domain, NMFS has worked with state, tribal, local and other Federal entities to develop planning forums that build to the extent possible on ongoing, locally led recovery efforts. NMFS defined "management units" based on jurisdictional boundaries as well as areas where local planning efforts were underway (Figure 1-3). It can be seen from the figure that the management units do not necessarily correspond to biological units, such as steelhead populations, but are defined for planning and administrative purposes. The Middle Columbia management units are

(1) Oregon; (2) Washington Gorge, which, in turn, is subdivided into three planning areas: White Salmon, Klickitat, and Rock Creek; (3) Yakima subbasin; and (4) Southeast Washington.

1.6 Management Unit Recovery Plans

Although NMFS has prepared this plan for the entire DPS, the management unit plans (Appendices A-E) are the work of local groups and county, state, Federal, and tribal entities within the Middle Columbia River region on both sides of the river. The management unit plans built on existing recovery plans, in particular, the Northwest Power and Conservation Council's subbasin plans, and targeted the specific ESA recovery needs of Middle Columbia steelhead.

- **Oregon Management Unit:** ***Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment (Oregon Steelhead Recovery Plan) (Appendix A).***

- **Washington Gorge Management Unit:** ***Recovery Plans for the Klickitat River (Appendix B) and Rock Creek (Appendix C) subbasin populations of Middle Columbia River steelhead. NMFS also prepared a draft plan for the White Salmon River extirpated population; however, the final White Salmon recovery plan will be incorporated into the Lower Columbia River domain plan.***

- **Southeast Washington Management Unit:** ***Snake River Salmon Recovery Plan for Southeast Washington (Southeast Washington Plan) (Appendix D)***

- **Yakima Management Unit:** ***Yakima Steelhead Recovery Plan (Appendix E)***

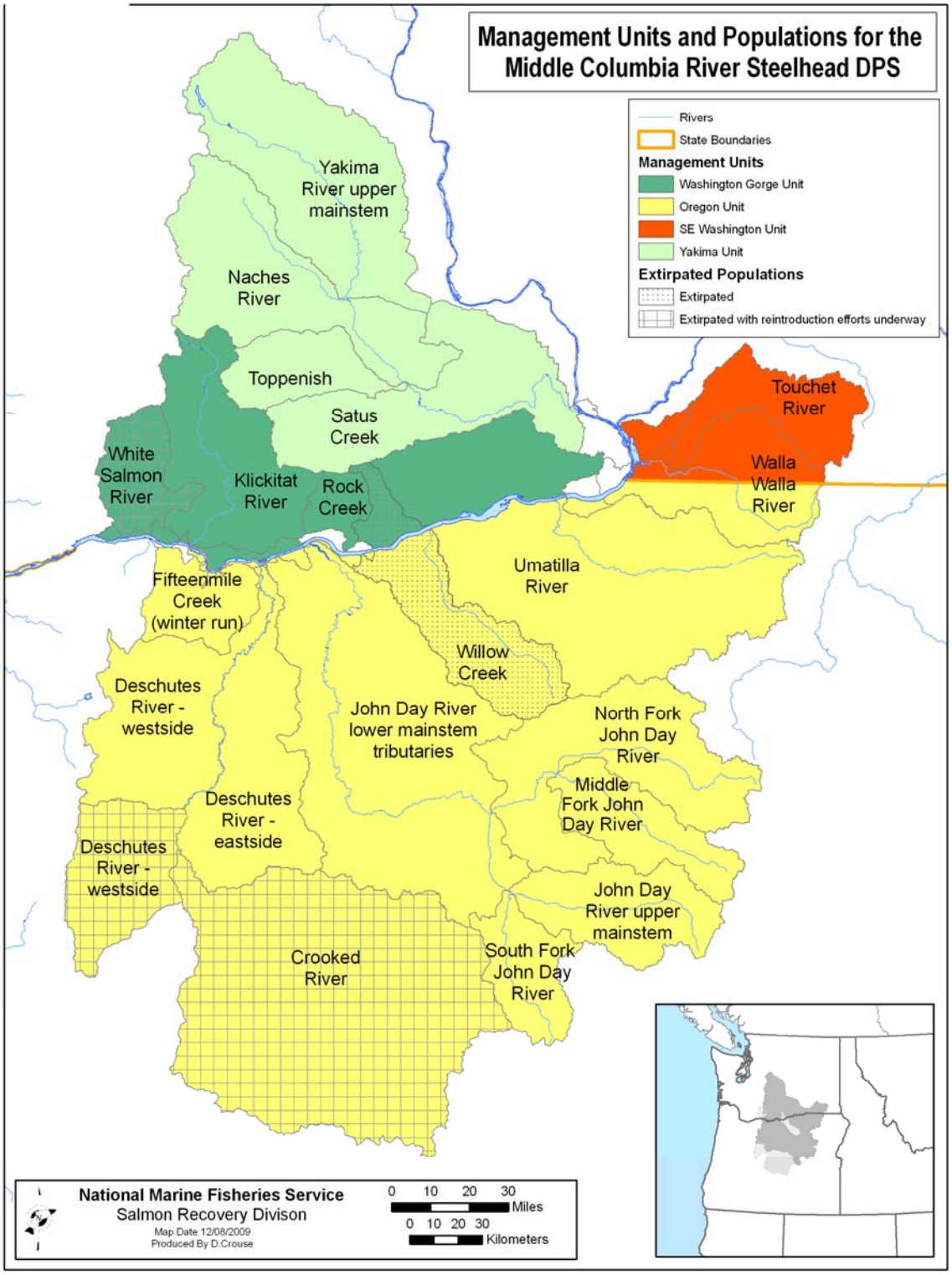


Figure 1-3. Management Units and Populations for the Middle Columbia River Steelhead DPS.

1.6.1 Oregon Steelhead Recovery Plan - Appendix A.

ODFW is the lead for the Conservation and Recovery Plan for Oregon Steelhead Populations in the Middle Columbia River Steelhead Distinct Population Segment (Oregon Steelhead Recovery Plan). ODFW drew together the Middle Columbia Recovery Planning Team, made up of ODFW staff biologists and representatives from eight other natural resource agencies, and a planning forum, the Mid-Columbia Sounding Board (MCSB). The MCSB is made up of representatives of local communities, agricultural water users, Federal and non-Federal land managers, governing bodies, Tribes, and industry and environmental interests. The role of the MCSB is to provide policy guidance in the development of all aspects of the plan and ensure locally appropriate and locally supported recovery actions needed to achieve species recovery goals. Population-specific management action development teams were drawn from the pool of natural resource agency staff on the Planning Team.

ODFW convened an "Expert Panel" of 12 biologists to examine limiting factors and threats for the 10 independent steelhead populations in Oregon. The recovery planning team also made its own evaluation. More detail on the Expert Panel process is available in the Oregon Steelhead Recovery Plan, Section 8, and in a report by the panel (Mid-Columbia Expert Panel 2006). The Oregon Steelhead Recovery Plan also drew on the relevant subbasin plans, ODEQ reports, NMFS' limiting factors modules, ODFW reports, and other sources.

Oregon Middle Columbia Steelhead Populations:
Fifteenmile Creek
Deschutes River Eastside
Deschutes River Westside
Deschutes/Crooked River (extirpated)
Lower Mainstem John Day
Upper Mainstem John Day
North Fork John Day
Middle Fork John Day
South Fork John Day
Umatilla River
Walla Walla River (also partially in Washington State)
Willow Creek (extirpated)

1.6.2 Washington Gorge Management Unit Recovery Plan (Appendices B and C)

The Washington Gorge Management Unit comprises three subbasins in south-central Washington: the areas drained by the Klickitat River, Rock Creek, and the White Salmon River. The steelhead populations in these subbasins are part of the Cascades Eastern Slope Tributaries major population group. The Washington Gorge Management Unit Recovery Plan (the Washington Gorge Plan) is actually made up of three separate plans, one for each subbasin. Since there is not presently a Washington-State sponsored salmon recovery planning board for this area, NMFS staff drafted the three plans in collaboration with the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal agencies, state agencies, local governments, and the public.

The Columbia Gorge area within Washington State from Rock Creek east to Kennewick makes up Water Resource Inventory Area (WRIA) 31. The WRIA 31 planning unit is addressing steelhead habitat within the WRIA. The area contains Rock Creek and several smaller tributaries to the Columbia River with current and historical steelhead habitat. The ICTRT has designated steelhead in these smaller tributaries as part of the Willow Creek and Umatilla populations of the Middle Columbia steelhead DPS; however, there is very little further information currently available and no recovery plan was developed for them (see Appendix A to the Rock Creek management unit plan).

The Klickitat basin is in WRIA 30. The WRIA 30 planning unit is addressing steelhead habitat by reviewing water quality proposals developed primarily to fix flow and temperature problems in the Klickitat basin external to the Yakama Reservation. This recovery plan and the Klickitat Recovery Plan may be used by the WRIA 30 planning unit to help guide the review of proposals considered for funding.

The White Salmon River supported an historical population of Middle Columbia River steelhead, which was extirpated from its historical range in 1913 by the construction of Condit Dam at river mile 3.4. Condit Dam is scheduled for removal in 2010. In addition to steelhead, single populations of three listed ESUs of salmon (Lower Columbia River Chinook, Lower Columbia River Coho, and Columbia River Chum) spawn in the White Salmon River subbasin. The need for an ecosystem approach warrants addressing in one single plan all the listed salmonids that spawn in the White Salmon subbasin; for that reason, the White Salmon plan will be finalized as part of the Lower Columbia ESA Recovery Plan, scheduled to be completed in 2010. However, the delisting criteria, actions, and costs for Middle Columbia River steelhead in the White Salmon subbasin are included in this DPS plan in order to have all the information on the Middle Columbia DPS in one place.

Washington Gorge Steelhead Populations:
Rock Creek
Klickitat
White Salmon (functionally extirpated)[15]

1.6.3 Southeast Washington Plan (Appendix D)

The Snake River Salmon Recovery Board (SRSRB) developed the recovery plan for the Southeast Washington management unit, and entitled it the *Snake River Salmon Recovery Plan for Southeast Washington.* This plan is called the Southeast Washington Plan here in order to differentiate it from the forthcoming recovery plan for the five species of listed salmon and steelhead in the Snake River region (which includes parts of Washington, Oregon, and Idaho). The SRSRB is made up of government and tribal representatives, landowners, and private citizens, funded through the Washington Salmon Recovery Fund. The Board appointed a Regional Technical Team for technical and scientific assistance. In March 2006, NMFS accepted the SRSRB Plan, in combination with a NMFS Supplement regarding the Plan, as an Interim Regional Recovery Plan (March 14, 2006, 71 FR 13094).

[15] The ICTRT considers extirpated populations to be those that are entirely cut off from anadromy. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

Southeast Washington Steelhead Populations:
Walla Walla River (also partially in Oregon)
Touchet River

1.6.4 Yakima Steelhead Recovery Plan (Appendix E)

The Yakima Subbasin Fish and Wildlife Planning Board (YSPB) submitted the Draft Yakima Subbasin Salmon Recovery Plan to the Washington State Governor's Salmon Recovery Office on October 26, 2005. In May 2006, NMFS accepted the draft YSPB plan, in combination with a NMFS Supplement regarding the plan, as an Interim Regional Recovery Plan (May 3, 2006, 71 FR 26052). On April 5, 2006, the Yakima Subbasin Fish and Wildlife Planning Board and the Yakima River Basin Salmon Recovery Board were both dissolved by board resolutions. Their functions were then taken on by a new organization, the Yakima Basin Fish and Wildlife Recovery Board (YBFWRB), which includes representatives from the Yakama Nation, Benton, Kittitas, and Yakima counties, and 18 of the 24 municipalities in the Yakima Basin. Since the formation of the YBFWRB, revisions have been made to the original October 2005 draft to incorporate new information, improve clarity, and address issues identified in the NMFS supplement and comments received in response to publication in the Federal Register. A revised and updated portion of the draft plan, the Yakima Steelhead Recovery Plan, focuses on steelhead recovery needs, and was submitted to NMFS in early 2008 for inclusion in this Middle Columbia Steelhead Recovery Plan. (For more information see www.ybfwrb.org).

Yakima Basin Steelhead Populations:
Satus Creek
Toppenish Creek
Naches River
Upper Yakima River

1.7 Recovery Planning Modules

NMFS prepared two recovery planning "modules" to address system effects that transcend the geographic boundaries of individual subbasins, recovery domains, or management units. The modules provide detailed information on Columbia mainstem and estuary, through which Middle Columbia steelhead and other anadromous salmonids must pass as juveniles and returning adults.

1.7.1 Hydro Module

The Hydro Module summarizes the general effects of Columbia River mainstem hydropower projects on all 13 ESA-listed salmonids in the Columbia basin, including the limiting factors and threats and expected actions (including site-specific management actions), or strategy options, to address those threats. This module supports recovery plans for the Snake River, Upper Columbia, Middle Columbia, Lower Columbia, and Upper Willamette River species. It is a synthesis of information that has undergone public processes for review, including, but not limited to, the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion, Federal Energy Regulatory Commission (FERC) licensing proceedings, and Habitat Conservation Plans (HCPs). This module may be updated as additional information becomes available.

1.7.2 Estuary Module

The Estuary Module, which NMFS prepared in collaboration with the Lower Columbia Estuary Partnership, focuses on habitat in the lower Columbia River below Bonneville Dam and how that habitat affects the survival of ESA-listed chum, steelhead, Chinook, and coho from throughout the Columbia River basin. It identifies and prioritizes limiting factors and threats in the estuary, then identifies 23 broad actions whose implementation would reduce the threats and thus increase survival of salmon and steelhead during their time in the estuary. The module also estimates the cost of implementing each action over a 25-year period. A description of monitoring, research, and evaluation needs that are appropriate to the management actions is included as an appendix to the module.

1.8 Tribal Trust and Treaty Responsibilities

Northwest Indian Tribes have legally enforceable rights reserving to them a share of the salmon harvest. In the Treaties of 1855 between the U.S. government and the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe, the tribes, in exchange for the preponderance of their lands, reserved the rights to fish within their reservations and "at all other usual and accustomed places." The usual and accustomed places are understood to include the millions of acres of aboriginal land ceded to the United States in the 1855 treaties, which extends to the Upper Columbia and Snake River basins, and includes most of the geographic range of the Middle Columbia steelhead DPS. A complex history of treaties, executive orders, legislation, and court decisions have culminated in the recognition of tribes as co-managers who share management responsibilities and rights for fisheries in the Columbia Basin.

Achieving the basic purpose of the ESA (to bring the species to the point that it no longer needs the protection of the Act) may not by itself fully meet these rights and expectations, although it will lead to major improvements in the current situation. Ensuring a sufficient abundance of salmon to sustain harvest can be an important element in fulfilling trust and treaty rights as well as garnering public support for these plans. ESA and tribal trust responsibilities complement one another. Both depend on a steady upward trend toward ESA recovery and delisting in the near term, while making aquatic habitat, harvest, and land management improvements for the long term.

It is appropriate for recovery plans to take these considerations into account and plan for a recovery strategy that includes harvest. In some cases, increases in the naturally spawning populations may be sufficient to support harvest. In others, the recovery strategy may include appropriate use of hatcheries to support a portion of the harvest. So long as the overall plan is likely to achieve the recovery of the listed ESU/DPS, it will be acceptable as a recovery plan.

The NMFS Regional Administrator, in testimony before the U.S. Senate Indian Affairs Committee (June 2003), emphasized the importance of this co-manager relationship: "We have repeatedly stressed to the region's leaders, tribal and non-tribal, the importance of our co-management and trust relationship to the tribes. NMFS enjoys a positive working relationship

with our Pacific Northwest tribal partners. We view that relationship as crucial to the region's future success in recovery of listed salmon."

2. BIOLOGICAL BACKGROUND

This chapter summarizes the distribution, life history, and habitat needs of Middle Columbia River steelhead and reviews the basic concepts in salmonid biology needed to understand recovery goals and criteria.

2.1 Steelhead Distribution, Life History, and Habitat

The present distribution of steelhead extends from Kamchatka in Asia, east to Alaska, and down to southern California (NMFS 1999a), although the historical range of *O. mykiss* extended at least to the Mexico border (Busby et al. 1996). Middle Columbia River steelhead historically occupied nine major river systems and numerous minor systems on the east side of the Cascades Mountains within the states of Oregon and Washington (see previous Figure 1-1). These major tributaries to the Columbia River are the White Salmon, Deschutes, John Day, Klickitat, Umatilla, Walla Walla, and Yakima Rivers and Fifteenmile Creek and Rock Creek. The John Day River of central Oregon supports the largest naturally spawning, native group of steelhead in the region.

Four artificial propagation programs are considered part of the DPS: the Touchet River Endemic Summer Steelhead Program, the Yakima River Kelt Reconditioning Program, and the Umatilla River and Deschutes River steelhead hatchery programs.

The species *Oncorhynchus mykiss* exhibits perhaps the most complex suite of life history traits of any species of Pacific salmonid. These fish can be anadromous or freshwater residents (and under some circumstances, apparently yield offspring of the opposite form). Steelhead, the anadromous form of *O. mykiss*, are under NMFS jurisdiction, while the resident freshwater forms, usually called "rainbow" or "redband" trout, are under the jurisdiction of the U.S. Fish and Wildlife Service (see further discussion in Section 1.4 of this plan).

Steelhead can spawn more than once (iteroparous), whereas all other *Oncorhynchus* except cutthroat trout (*O. clarki*) spawn once and then die (semelparous). Iteroparity for Columbia Basin steelhead ranges from reported rates of 2-4 percent above McNary Dam (Busby et al. 1996) up to 17 percent in the unimpounded tributaries below Bonneville Dam (at RM 146.1) (Leider et al. 1986).

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. The "runs" are usually named for the season in which the peak occurs. Most steelhead can be categorized as one of two run types, based on their sexual maturity when they re-enter freshwater and how far they go to spawn. In the Pacific Northwest, summer steelhead enter freshwater between May and October and require several months to mature before spawning; winter steelhead enter freshwater between November and April with well-developed gonads and spawn shortly thereafter. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966, Roelofs 1983, Behnke 1992). Winter steelhead are also called ocean-maturing or coastal type, and summer steelhead, stream-maturing or inland type.

The Middle Columbia River steelhead DPS includes the only populations of inland winter steelhead in the United States, in the Klickitat River, White Salmon River, Fifteenmile Creek, and possibly Rock Creek.[16]

Steelhead spawn in clear, cool streams with suitable gravel size, depth, and current velocity. They may spawn in intermittent streams that provide appropriate conditions for spawning and incubation (Barnhart 1986, Everest 1973). Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Steelhead may enter streams and arrive at spawning grounds weeks or even months before they spawn and are therefore vulnerable to disturbance and predation. They need cover, in the form of overhanging vegetation, undercut banks, submerged vegetation, submerged objects such as logs and rocks, floating debris, deep water, turbulence, and turbidity. Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types (Bambrick et al. 2004) (Table 2-1). Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months before hatching.

Table 2-1. Key habitat requirements by life stage and time period for steelhead.

Life Stage	Relevant Months	Key Habitat Descriptions
Spawning	Mar-Jun	Riffles, tailouts, and glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity.
Incubation	Mar-Jun	Riffles, tailouts, and glides as described for spawning, with sufficient flow for egg and alevin development.
Fry Colonization	May-Jul	Shallow, slow velocity areas within the stream channel, often associated with stream margins.
Active Rearing	0-age May-Jul; 1-age, Mar-Oct; 2+-age, Mar-Oct	Gravel and cobble substrates with sufficient depth and velocity, and boulder/large cobble/wood obstruction to reduce flow and concentrate food.
Inactive Rearing	0,1-age Oct-Mar	Stable cobble/boulder substrates with interstitial spaces.
Migrant	1-age, Mar-Jun 2+-age, Mar-Jun	All habitat types having sufficient flow for free movement of juvenile migrants.
Prespawning Migrant	Winter, Nov-Apr Summer, All	All habitat types having sufficient flow for free movement of sexually mature adult migrants.
Prespawning Holding	Winter, Dec-May Summer, All	Relatively slow, deep-water habitat types typically associated with (or immediately adjacent to) the main channel.

Young steelhead typically rear in streams for some time before migrating to the ocean as smolts. Steelhead smolts have been shown to migrate at ages ranging from 1 to 5 years throughout the

[16] See Rock Creek Recovery Plan

Columbia Basin, but most steelhead generally smolt after 2 years in freshwater (Busby et al. 1996). Some juveniles move downstream to rear in larger tributaries and mainstem rivers.

Based on catch data, juvenile steelhead tend to migrate directly offshore during their first summer, rather than migrating nearer to the coast. Maturing Columbia River steelhead are found off the coast of Northern British Columbia and west into the North Pacific Ocean (Busby et al. 1996). Available fin-mark and coded-wire tag data suggest that winter steelhead tend to migrate farther offshore but not as far north into the Gulf of Alaska as summer steelhead (Burgner et al. 1992). At the time adults are (re-)entering freshwater, tagging data indicate that immature Columbia River steelhead are out in the mid-North Pacific Ocean.

Most steelhead spend 2 years in the ocean (range 1 to 4 years) before migrating back to their natal streams (Shapovalov and Taft 1954; Ward and Slaney 1988). Once in the river, steelhead apparently rarely eat and grow little, if at all. These combined behaviors produce fish that range between 3 and 7 years of age at the time of spawning.

2.2 DPS Biological Structure

Salmonid species' homing propensity (their tendency to return to the locations where they originated) creates unique patterns of genetic variation and connectivity that mirror the distribution of their spawning areas across the landscape. Diverse genetic, life history, and morphological characteristics have evolved over generations, creating runs highly adapted to diverse environments. It is this variation that gives the species as a whole the resilience to persist over time.

Historically, a salmon ESU or, as in this case, steelhead DPS typically contained multiple populations connected by some small degree of genetic exchange by straying spawners. Thus, the overall biological structure of the ESU/DPS is hierarchical; spawners in the same area of the same stream will share more characteristics than those in the next stream over. Fish whose natal streams are separated by hundreds of miles will have less genetic similarity. The ESU or DPS is essentially a metapopulation defined by the common characteristics of populations within a geographic range. Recovery planning efforts focus on this biologically based hierarchy (Figure 2-1).

McElhany et al. (2000) formally identified two levels in this hierarchy for recovery planning purposes: the evolutionarily significant unit (ESU) or distinct population segment (DPS) and the independent population. The ICTRT identified an additional level between the population and ESU/DPS levels, which they call a major population group (MPG) (McClure et al. 2003).

2.2.1 Distinct Population Segments

An ESU or DPS is a distinctive group of Pacific salmon or steelhead that is uniquely adapted to a particular area or environment. Because of the hierarchical structure of salmonid populations, the concept of "distinctive group" has received considerable attention and refinement. An ESU is defined as a group of Pacific salmon that is "substantially reproductively isolated from other conspecific units and represents an important component of the evolutionary legacy of the species" (Waples et al. 1991). A "population segment" is considered distinct (a DPS and hence, like ESUs, considered a "species" for purposes of conservation under the ESA) if it is discrete

from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, or if it occupies an unusual or unique ecological setting, or if its loss would represent a significant gap in the species' range. ESUs/DPSs may contain multiple populations that are connected by some degree of migration, and hence may have a broad geographic range across watersheds and river basins.[17]

2.2.2 Major Population Groups

Within an ESU/DPS, independent populations can be grouped into larger populations that share similar genetic, geographic, and/or habitat characteristics (McClure et al. 2003). These "major groupings" of populations (MPGs) are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between ESUs/DPSs. The relationship between ESU/DPS, MPG, and independent populations is depicted in Figure 2-1.

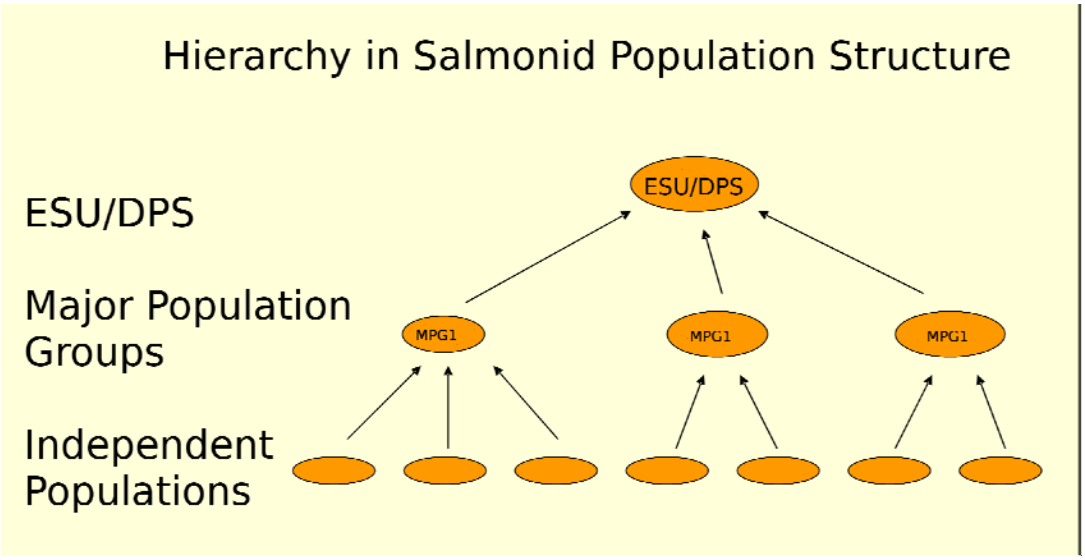


Figure 2-1 Hierarchical levels of salmonid species structure as defined by the TRTs for ESU/DPS recovery planning.

2.2.3 Independent Populations

McElhany et al. (2000) defined an independent population as follows:

> *"…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not*

[17] See Section 1.4 for discussion of the relationship of anadromous vs resident *O. mykiss.*

substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."

2.3 Middle Columbia River Steelhead MPGs and Populations

The ICTRT stratified the Middle Columbia River steelhead populations into MPGs based on ecoregion characteristics, life history types, and other geographic and genetic considerations. It identified four MPGs: Cascades Eastern Slope Tributaries, Yakima Basin, John Day Basin, and Umatilla/Walla Walla. The John Day River MPG is wholly within Oregon and the Yakima Basin MPG is wholly within Washington. The other two include populations on both sides of the Oregon/Washington boundary (see Figure 2-2). The management units that NMFS defined for planning purposes do not cross state boundaries; thus, the two bi-state MPGs have populations in different management units. The headwaters of the Walla Walla River are in Oregon and the river joins the Columbia in Washington, but the Walla Walla River steelhead are functionally one population, covered in two management unit plans.

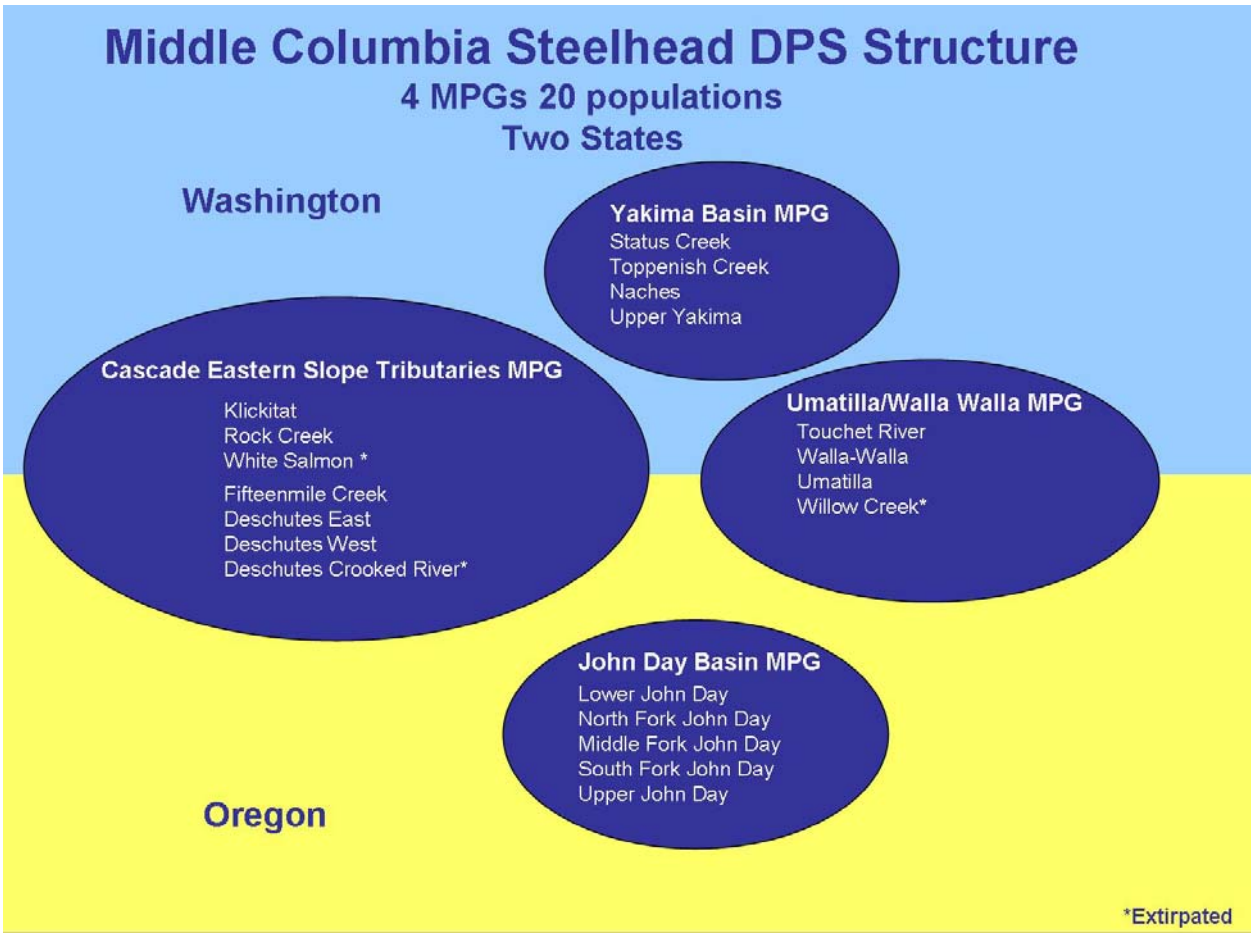


Figure 2-2 Middle Columbia Steelhead DPS Structure.

The ICTRT (McClure et al. 2003) identified 20 historical populations of Middle Columbia steelhead, shown in Figure 2-3. This identification was based on genetic information, geography, life history traits, morphological traits, and population dynamics. Seventeen of these populations

are extant, and three extirpated (White Salmon River, Deschutes Crooked River above Pelton Dam, and Willow Creek).

Three hatchery programs produce steelhead that are considered to be part of the DPS: the Round Butte hatchery program on the Deschutes River, the Umatilla River hatchery program, and the endemic summer steelhead program on the Touchet River (71 FR 834). In addition, a program to improve kelt (post-spawned adult) survival for the four Yakima Basin populations is also considered part of the DPS. Within the range of the Middle Columbia steelhead DPS, non-listed hatchery steelhead are released into the Klickitat basin, the Walla Walla (on the Washington side), the Touchet, and the White Salmon to support harvest.

2.3.1 Cascades Eastern Slope Tributaries MPG

The Cascades Eastern Slope Tributaries MPG includes three extant steelhead populations in Oregon and two in Washington, with one extirpated population in each state (Figure 2-3). This MPG has a geographically complex range, embracing one major river system – the Deschutes – and several smaller subbasins on both sides of the river. The Oregon populations are covered in the Oregon Steelhead Recovery Plan and the Washington populations in the Washington Gorge Management Unit plans. The Deschutes subbasin stretches over 10,700 square miles of land in central Oregon and covers 11 percent of Oregon's land area. Deschutes County, with the cities of Bend, Redmond, and Sisters, and Crook County, with Madras and Prineville, are among the fastest growing counties in the nation. The Confederated Tribes of Warm Springs Indian Reservation of approximately 641,000 acres includes several tributaries of the Deschutes and is bordered to the south and east by the mainstem Deschutes and the Round Butte dam complex. The Washington Gorge populations are in rural areas with agricultural development in the lowlands and forest uses in the uplands. The headwaters of the Klickitat River are within the Yakama Reservation.

2.3.2 John Day River MPG

The John Day River steelhead populations are currently managed entirely as wild populations. The John Day Basin is wholly within Oregon. The John Day River, which flows west from the Blue Mountains and then north through a deeply carved, basaltic landscape, is the second-longest free-flowing river in the continental United States. The towns within the subbasin with the largest populations are John Day, Prairie City, and Condon, all with less than 2000 residents. The largest tributary to the John Day River is the North Fork John Day, which originates in the Wallowa-Whitman National Forest in the Blue Mountains at elevations near 8000 feet. The North Fork John Day River flows westerly for 112 miles and joins the mainstem near Kimberly (RM 185), 15 miles below the town of Monument.

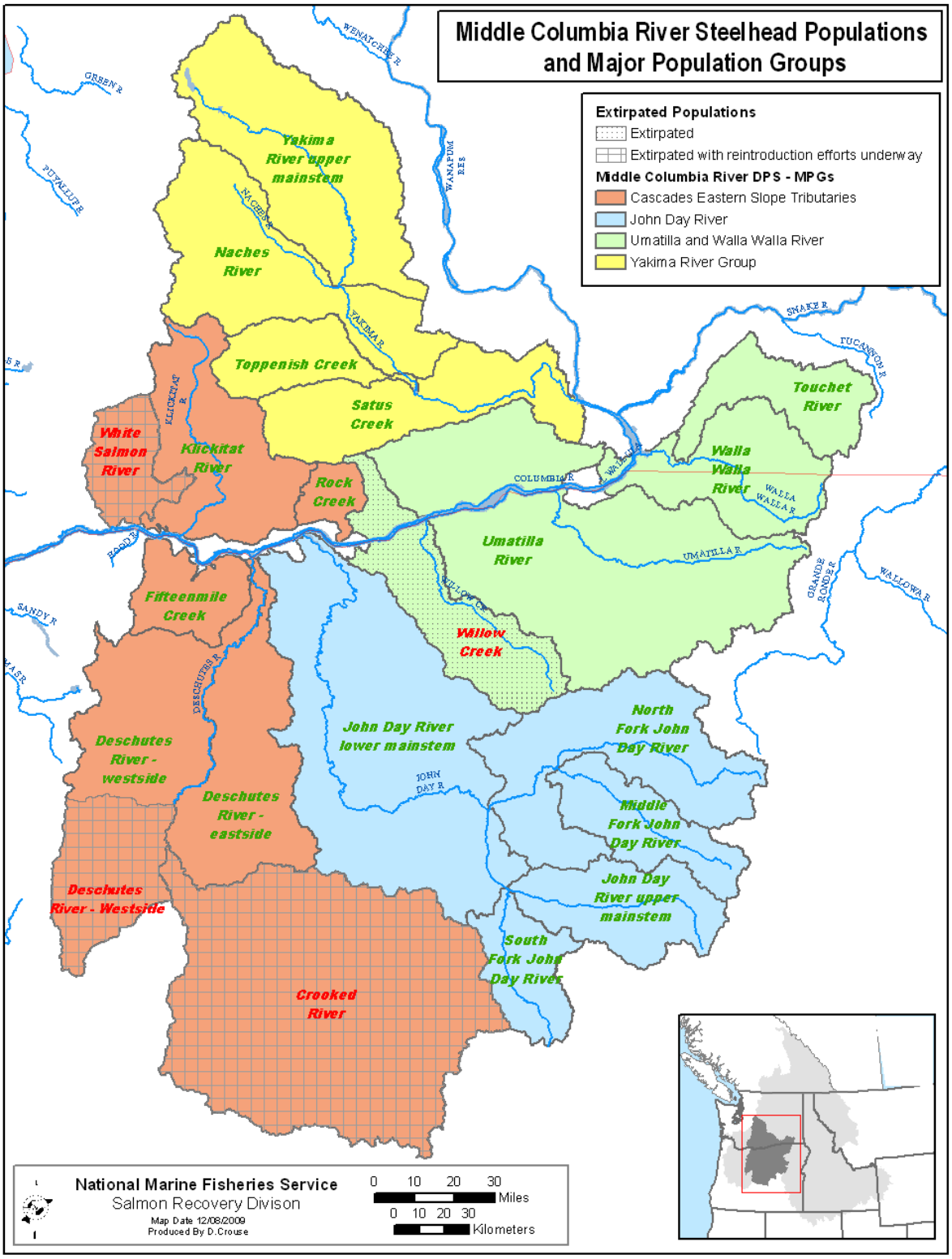


Figure 2-3 Middle Columbia River Steelhead Populations and Major Population Groups.

2.3.3 Umatilla/Walla Walla MPG

The Umatilla River is in Oregon, the Touchet River in Washington, and the Walla Walla River in both states. The Umatilla River originates in the Blue Mountains of northeastern Oregon and flows north and west to enter the Columbia River at river mile (RM) 289. The towns of Pendleton, Hermiston, and Umatilla are located along the Umatilla mainstem. The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) comprises 271 square miles on both sides of the river. Aside from the towns, land use is mostly dryland and irrigated agriculture.

The Walla Walla River also originates in Oregon and flows northwest into Washington to join the Columbia, while the Touchet originates in the Blue Mountains on the Washington side and flows south and west into the Walla Walla. The river valley is extensively and intensively irrigated, with timber harvest in the high and mid elevations. Settlements include the city of Walla Walla, population 26,500, on Mill Creek, a tributary of the Walla Walla River, and the smaller towns of College Place, Dayton, and Waitsburg, Washington, and Milton Freewater, Oregon.

This MPG also includes several small tributaries (Chapman, Wood Gulch, Pine, Old Lady, Alder and Glade Creeks) located east of Rock Creek in Washington State that drain into the Columbia upstream of John Day Dam. The ICTRT has determined that four of these eastern Washington tributaries are minor spawning areas of the extirpated Willow Creek population – Pine Creek, Wood Creek, Old Lady Creek and Chapman Creek. Data needs to be collected regarding steelhead use in these small tributaries of the Columbia.

2.3.4 Yakima River MPG

The Yakima River MPG is wholly within Washington State. Cities and towns along the Yakima River include Cle Elum and Ellensburg in Kittitas County, Yakima and several smaller towns in Yakima County, and Prosser and Richland along the lower river in Benton County. The lowlands are extensively developed for irrigated agriculture, though significant amounts of complex floodplain habitat remain. Interstate highway 82 follows the river for about two-thirds of its length and scenic highways follow the Naches and Tieton rivers. The least developed areas are the uplands in the Eastern Cascade Mountains and the Satus Creek subbasin on the Yakama Indian Reservation. The population of the Yakima basin is approximately 300,000.

The Yakima subbasin is growing in population and most likely will continue to grow, and planners expect that the bulk of land use and development for future population growth will occur in proximity to the Yakima River mainstem and major tributary corridors where there is water, an existing core of rail and road transportation infrastructure, major concentrations of urban services, and high-value shoreline property.

Water storage and delivery systems have major impacts on the basin's hydrology. An extensive water supply system run by the Bureau of Reclamation's Yakima Irrigation Project stores and delivers water for over 400,000 acres of irrigated agriculture and, to a lesser degree, industrial, domestic, and hydropower use. Management of water storage and delivery systems results in streamflows across the subbasin that are often out of phase with the life history requirements of native salmonids (Fast et al. 1991; Stanford, Snyder et al. 2002) and riparian species such as cottonwoods (Braatne and Jamieson 2001).

2.4 Viable Salmonid Populations

NMFS scientists measure salmon recovery in terms of four parameters, called the viable salmonid population (VSP) parameters: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000).

2.4.1 Abundance and Productivity

Abundance refers to spawners (adults on the spawning ground), measured over a time series, i.e. some number of years. The ICTRT often uses a recent 10- or 12-year geometric mean of natural spawners as a measure of current abundance.

The productivity of a population (the average number of surviving offspring per parent) is a measure of the population's ability to sustain itself. Productivity can be measured as spawner:spawner ratios (returns per spawner or recruits per spawner) (or adult progeny to parent), annual population growth rate, or trends in abundance. Population-specific estimates of abundance and productivity are derived from time series of annual estimates, typically subject to a high degree of annual variability and sampling-induced uncertainties. The ICTRT recommends estimating current intrinsic productivity using spawner-to-spawner return pairs from low to moderate escapements over a recent 20-year period.

Abundance and productivity are linked, as populations with low productivity can still persist if they are sufficiently large, and small populations can persist if they are sufficiently productive. A viable population needs sufficient abundance to maintain genetic health and to respond to normal environmental variation, and sufficient productivity to enable the population to quickly rebound from periods of poor ocean conditions or freshwater perturbations.

The VSP guidelines for abundance recommend that a viable population should be large enough to have a high probability of surviving environmental variation observed in the past and expected in the future; be resilient to environmental and anthropogenic disturbances; maintain genetic diversity; and support/provide ecosystem functions (McElhany et al. 2000).

Viable populations should demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on the average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels (ICTRT 2005).

The ICTRT considers populations with fewer than 500 individuals at high risk for inbreeding depression and a variety of other genetic concerns (McClure et al. 2003). Because of this, it considers any population fewer than 500 individuals to be minimally viable, regardless of its intrinsic productivity.

Abundance should be high enough that 1) declines to critically low levels would be unlikely, assuming recent historical patterns of environmental variability and intrinsic productivity; 2) compensatory processes provide resilience to the effects of short-term perturbations; and 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns) (ICTRT 2005).

2.4.2 Spatial Structure and Diversity

Spatial structure and diversity considerations are combined in the evaluation of a salmonid population's status because they often overlap. A population's spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000, p. 18). Diversity refers to the distribution of traits within and among populations. Some traits are completely genetically based, while others, including nearly all morphological, behavioral, and life history traits, vary as a result of a combination of genetic and environmental factors (ibid. p. 19).

Populations with restricted distribution and few spawning areas are at a higher risk of extinction as a result of catastrophic environmental events, such as a landslide, than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, experiences more natural exchange of gene flow and life history characteristics.

Population-level diversity is similarly important for long-term persistence. Populations exhibiting greater diversity are generally more resilient to short-term and long-term environmental changes. Phenotypic diversity, which includes variation in morphology and life history traits, allows more diverse populations to use a wider array of environments, and protects populations against short-term temporal and spatial environmental changes. Underlying genetic diversity provides the ability to survive long-term environmental changes.

Because neither the precise role that diversity plays in salmonid population viability nor the relationship of spatial processes to viability is completely understood, the ICTRT adopted the principle from McElhany et al. that historical spatial structure and diversity should be taken as a "default benchmark," on the assumption that historical, natural populations did survive many environmental changes and therefore must have had adequate spatial structure and diversity.

2.5 Critical Habitat

The ESA requires the Federal government to designate "critical habitat" for any species it lists under the ESA. The Act defines critical habitat as areas that contain physical or biological features that are essential for the conservation of the species, and that may require special management or protection. Critical habitat designations must be based on the best scientific information available, in an open public process, within specific timeframes. On September 2, 2005 NMFS published a final rule (70 FR 52630, NMFS 2005b) to designate critical habitat for Middle Columbia River steelhead and 12 other ESUs/DPSs of salmon and steelhead (Figure 2-4). The final rule took effect on January 2, 2006.

A critical habitat designation does not set up a preserve or refuge, and critical habitat requirements do not apply to citizens engaged in activities on private land that do not involve a Federal agency. The designation applies only when Federal funding, permits, or projects are involved. Under section 7 of the ESA, all Federal agencies must ensure that any actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species, or destroy or adversely modify its designated critical habitat. Before critical habitat is designated, careful consideration must be given to its economic impacts, impacts on national security, and other relevant impacts. The Secretary of Commerce may exclude an area from

critical habitat if the benefits of exclusion outweigh the benefits of designation, unless excluding the area will result in the extinction of the species concerned.

For anadromous fish, the essential features of designated critical habitat include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water, velocity, space, and safe passage. These features also describe the habitat factors associated with viability for all ESUs/DPSs. The specific habitat requirements for each ESU/DPS differ by life history type and life stage.

NMFS' Critical Habitat Assessment Review Team (Bambrick et al. 2004) rated the conservation value of all watersheds supporting populations of Middle Columbia River steelhead. The team identified the "primary constituent elements" of critical habitat for steelhead, i.e., the physical and biological elements that support one or more life stages and are considered essential to the conservation of the species (Table 2-2).

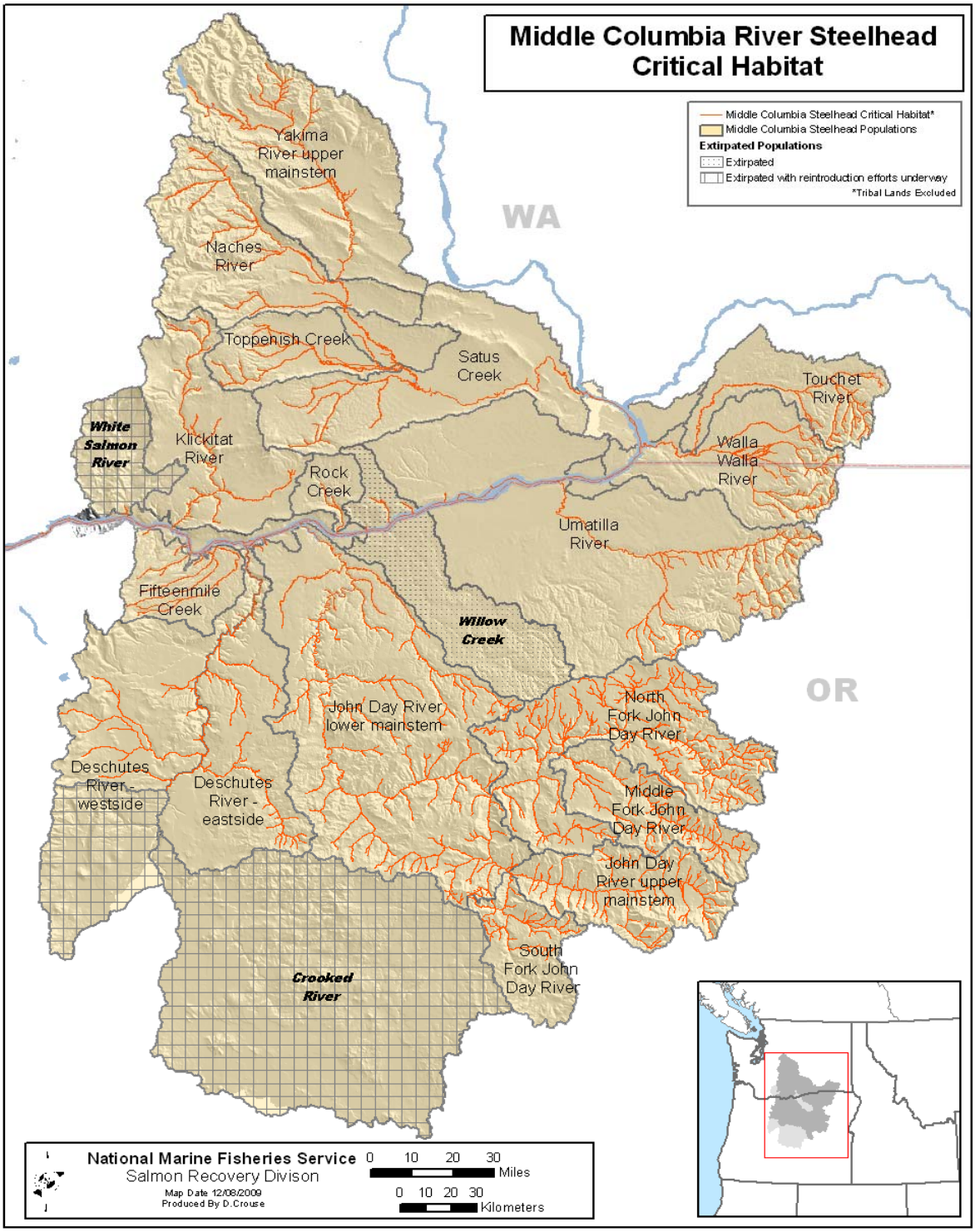


Figure 2-4. Middle Columbia Steelhead Critical Habitat[18] (NMFS 2005b)

[18] Critical habitat designation does not apply to the streams or stream reaches that are on tribal lands. However, the pattern of tribal vs nontribal ownership is too complex to differentiate at the scale of this map.

Table 2-2 Types of sites and essential physical and biological features designated as PCEs for steelhead, and the life stage each PCE supports.

Site	Essential Physical and Biological Features	ESU/DPS Life Stage
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity and floodplain connectivity	Juvenile growth and mobility
	Water quality and forage	Juvenile development
	Natural cover[a]	Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover[b]	Juvenile and adult mobility and survival
Estuarine areas	Free of obstruction, water quality and quantity, and salinity	Juvenile and adult physiological transitions between salt and freshwater
	Natural cover,[a] forage,[b] and water quantity	Growth and maturation
Nearshore marine areas	Free of obstruction, water quality and quantity, natural cover,[a] and forage[b]	Growth and maturation, survival
Offshore marine areas	Water quality and forage[b]	Growth and maturation

[a] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

[b] Forage includes aquatic invertebrate and fish species that support growth and maturation.

NMFS recognizes that salmon habitat is dynamic and that present understanding of areas important for conservation will likely change as recovery planning sheds light on areas that can and should be protected and restored, such as areas upstream of barriers where steelhead could be re-established into historical habitat. One example is the area upstream of Pelton Dam, of which the final rule designating critical habitat stated,

> " . . . the CHART agreed with the comments that areas upstream of Pelton Dam may be essential for this ESU as well, citing recent efforts to re-establish steelhead into historical habitat above this dam. However . . . at the present time we do not have information allowing us to determine that the specific areas within the geographical area occupied by the species are inadequate for conservation, such that we can make a determination that currently unoccupied areas above dams are essential for conservation. We will revise the designation if ongoing recovery planning indicates that specific areas above these dams warrant designation as critical habitat" (70 FR 52630, September 2, 2005, NMFS 2005a).

NMFS will update its critical habitat designations as needed, based on information developed during recovery plan implementation. Critical habitat designations are one element to consider in identifying and prioritizing recovery actions.

3. RECOVERY GOALS AND DELISTING CRITERIA

In this chapter we describe in greater detail the recovery goals in the management unit plans and the delisting criteria NMFS will use in future reviews of the Middle Columbia steelhead DPS. The recovery goals that are incorporated into a locally developed recovery plan may include delisting and other "broad sense" goals. The delisting criteria are a NMFS determination and may include both technical and policy considerations. Delisting criteria must meet the ESA requirements, while recovery may be defined more broadly. Broad sense recovery goals are goals defined in the recovery planning process that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values. A third term used in this recovery plan is recovery "scenarios" (Section 3.3). Recovery scenarios are combinations of viability status for individual populations within the DPS that will meet the ICTRT criteria for overall DPS viability.

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria which, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). These criteria are of two kinds: the biological viability criteria, which deal with population or demographic parameters, and the "threats" criteria, which relate to the five listing factors detailed in the ESA (see Sections 1.1 and 3.3 of this Plan). The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B) for the delisting decision.

The delisting criteria are based on the best available scientific information and incorporate the most current understanding of the DPS and the threats it faces. As this recovery plan is implemented, additional information will become available that can increase certainty about whether the threats have been abated, whether improvements in population and DPS status have occurred, and whether linkages between threats and changes in salmon status are understood. These criteria will be assessed through an adaptive management program under development for the Plan, and NMFS may review the criteria if appropriate during its 5-year reviews of the DPS.

For these status reviews, NMFS intends to rely strongly on the advice of the TRTs and recommendations of local recovery boards. However, NMFS has ultimate responsibility for final recovery plans and delisting decisions, and must take into account all relevant information, including, but not limited to, biological and policy considerations developed in the recovery planning process. NMFS has clarified, through Federal Register Notices on interim and proposed recovery plans, how it applies the TRT products to the plans (e.g., 71 FR 13094, Availability of ESA Draft Snake River Salmon Recovery Plan for Southeast Washington and Supplement to that draft; 71 FR 26052, Availability of Draft Yakima Subbasin Salmon Recovery Plan; 72 FR 57303, Adoption of ESA Recovery Plan for Upper Columbia Spring Chinook and Steelhead).

3.1 Biological Viability Criteria

In 2007, the ICTRT completed its Technical Review Draft of *Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs* (ICTRT 2007a). Biological viability criteria are quantitative metrics that describe DPS characteristics associated with a low risk of extinction for

the foreseeable future. These criteria are based on the VSP parameters of abundance, productivity, spatial distribution, and diversity, according to guidelines developed by NOAA's Northwest Fisheries Science Center and published as a NOAA Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000, ICTRT 2007a). The ICTRT calculated varying levels of risk of extinction and related the risk levels to their criteria.

3.1.1 DPS Viability Criterion

Since MPGs are geographically and genetically cohesive groups of populations, they are critical components of ESU/DPS spatial structure and diversity. Having all MPGs within an ESU/DPS at low risk provides the greatest probability of persistence for the ESU/DPS. The DPS viability criterion defined by the ICTRT (ICTRT 2007a) is as follows:

> **All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS[19] should be at low risk.**

The ICTRT explains that the major objectives of the ESU/MPG-level viability criteria are to ensure preservation of basic historical metapopulation processes, including: 1) genetic exchange across populations within an ESU over a long time frame; 2) the opportunity for neighboring populations to serve as source areas in the event of local population extirpations; 3) populations distributed within an ESU so that they are not all susceptible to a specific localized catastrophic event. In addition, the presence of viable populations across MPGs would preserve a high level of diversity, promoting long-term evolutionary potential for adaptation to changing conditions (ICTRT 2007a; see also Section 2.4 of this plan, which explains the VSP parameters).

3.1.2 Major Population Group Viability Criteria

The ICTRT recommended MPG-level viability criteria that take into account the level of risk associated with the MPG's component populations (Figure 3-1). While individual populations meeting viability criteria are expected to have low risk of extinction, the MPG-level criteria ensure robust functioning of the metapopulation and provide resilience in case of catastrophic loss of one or more populations. MPG viability depends on the number, spatial arrangement, and diversity associated with its component populations. The ICTRT developed the following MPG-level criteria considering relatively simple and generalized assumptions about movement or exchange rates among individual populations. In developing these criteria, the ICTRT assumed that catastrophes do not increase dramatically in frequency, that populations are not lost permanently (because of catastrophe or anthropogenic impacts), and that permanent reductions in productivity, including long-term, gradual reductions in productivity, do not occur (ICTRT 2005).

[19] The Middle Columbia steelhead DPS has four extant and no extirpated MPGs. The three extirpated populations are addressed as part of the MPG-level criteria.

Major Population Group Viability Criteria (ICTRT 2007a)

The following five criteria should be met for an MPG to be regarded as at low risk (viable):

1. At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.

2. At least one population should be classified as "Highly Viable."

3. Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as "Very Large," "Large," or "Intermediate," generally reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.

4. All major life history strategies (e.g. spring and summer-run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.

5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU/DPS recovery.

Figure 3-1. Major Population Group Viability Criteria (ICTRT 2007a).

Specifically, the first criterion for one-half of the populations to meet "viability standards" refers to the "Viable" standard, or less than 5 percent risk of extinction within 100 years. In the second criterion, "Highly Viable" means less than 1 percent risk of extinction within 100 years. These criteria follow recommendations in McElhany et al. 2000. The presence of viable populations in each of the extant MPGs and some number of highly viable populations distributed throughout the DPS would result in sustainable production across a substantial range of environmental conditions. This distribution would preserve a high level of diversity within the DPS, and would promote long-term evolutionary potential for adaptation to changing conditions. The presence of multiple, relatively nearby, highly viable, viable, and maintained populations acts as protection against long-term impacts of localized catastrophic loss by serving as a source of re-colonization. These criteria are consistent with recommendations for other ESUs in the Pacific Northwest (e.g., McElhany et al. 2006, Ruckelshaus et al. 2002) (ICTRT 2007a).

3.1.3 Population-Level Viability Criteria

To be determined to be viable, populations should meet criteria for all four VSP parameters (abundance, productivity, spatial structure, and diversity). The abundance and productivity criteria are related to population size. The ICTRT developed criteria for characterizing the relative size and complexity of Interior Columbia Basin steelhead populations based on their analysis of the intrinsic or historical potential habitat available to the population (ICTRT 2005). This analysis used available Geographic Information System (GIS) data layers showing stream characteristics (e.g. channel width, gradient, valley confinement) and empirically derived relationships between habitat type, stream structure, landscape processes, and spawning. The ICTRT built a model that also incorporated information from local biologists and recovery planners to identify natural barriers to migration and other local variations (ICTRT 2007a).

Middle Columbia steelhead spawn in a wide range of tributary drainage areas, from small creeks, e.g. Fifteenmile Creek or Rock Creek, to very large rivers, such as the Lower John Day. The ICTRT categorized historical population sizes as Basic, Intermediate, Large, and Very Large, and set minimum abundance thresholds for viable steelhead populations of each type (Table 3-1). The abundance thresholds are associated with minimum productivity thresholds, based on modeling studies described in ICTRT 2007a and 2007b. As explained in Section 2.4.1, abundance and productivity are linked, within limits; above a certain threshold, higher productivity can compensate for lower abundance and vice versa.

Of the 20 Middle Columbia steelhead populations (including the three extirpated populations), five are categorized as Basic, eight as Intermediate, five as Large, and two as Very Large (ICTRT 2007a). Table 3-1 shows the minimum abundance and productivity thresholds for the Middle Columbia steelhead populations to have a 95 percent probability of persistence for the next 100 years.

Table 3-1. Abundance and Productivity Thresholds (ICTRT 2007).

Major Population Grouping	Population	Population Size	Abundance Threshold	Productivity Threshold
Cascades Eastern Slope Tributaries	White Salmon (functionally extirp.)	Basic	500	1.56
	Klickitat R.	Intermediate	1000	1.35
	Fifteenmile Cr.	Basic	500	1.56
	Deschutes R. East	Intermediate	1000	1.35
	Deschutes R. West	Large[1]	1500	1.26
	Rock Cr.	Basic	500	1.56
	Crooked River (Extirp.)	Very Large	2250	1.19
John Day River	Lower Mainstem JD	Very Large	2250	1.19
	North Fork John Day	Large	1500	1.26
	Middle Fork John Day	Intermediate	1000	1.35
	South Fork John Day	Basic	500	1.56
	Upper Mainstem JD	Intermediate	1000	1.35
Umatilla / Walla Walla Rivers	Umatilla R.	Large	1500	1.26
	Walla Walla R.	Intermediate	1000	1.35
	Touchet R.	Intermediate	1000	1.35
	Willow Crk. (Extirp.)	Intermediate	1000	1.35
Yakima River Group	Satus Cr.	Intermediate[20]	1000	1.35
	Toppenish Cr.	Basic	500	1.56
	Naches R.	Large	1500	1.26
	Upper Yakima	Large	1500	1.26

[1]This population is treated as Intermediate in size with respect to abundance and productivity criteria because of constraints to currently accessible habitat (i.e. Pelton Dam).

Abundance and productivity

[20] For the historical population analysis, the ICTRT included the mainstem Yakima habitat below the confluence of Satus Creek in the Satus Creek population, making it Intermediate in size. However, if the mainstem component is lumped instead with mainstem Yakima River habitat upstream of Satus, the Satus Creek population would drop to Basic size. The Yakima plan discusses this question in more detail in Section 4.1.1.

The ICTRT defined abundance and productivity criteria for Middle Columbia steelhead populations (ICTRT 2005 and 2007) based on analyses of the intrinsic potential of the historically available habitat, the locations and sizes of major and minor spawning areas, and, within these areas, the abundance and productivity relationships that would result in a probability of low risk of extinction within 100 years (see Table 3-1). The abundance "thresholds" shown in the table represent the number of spawners needed for a population of the given size category to achieve the 5 percent (low) risk level at a given productivity. Abundance thresholds are 500, 1000, 1500, and 2250 for population sizes of Basic, Intermediate, Large, and Very Large, respectively, with productivity of 1.56, 1.35, 1.26, and 1.19, respectively.

Spatial structure and diversity

Spatial structure and diversity criteria are more complex. The ICTRT cautions that there is a good deal of uncertainty in assessing the status of spatial structure and diversity in a population. These criteria are based on a set of biological goals and the mechanisms that achieve those goals, and are specific to each population.

The ICTRT defined two goals, or biological or ecological objectives, that spatial structure and diversity criteria should achieve:

- Maintaining natural rates and levels of spatially mediated processes. This goal serves (1) to minimize the likelihood that populations will be lost due to local catastrophe, (2) to maintain natural rates of recolonization within the population and between populations, and (3) to maintain other population functions that depend on the spatial arrangement of the population.

- Maintaining natural patterns of variation. This goal serves to ensure that populations can withstand environmental variation in the short and long terms (ICTRT 2007a).

3.1.4 Recovery Scenarios

Populations within the DPS are the units whose risk levels collectively determine MPG viability and the likely persistence of the DPS. The ICTRT recommended that all MPGs in an ESU/DPS should be viable before the ESU/DPS can be considered at low risk of extinction. However, it may not be necessary for all of the populations to attain low risk in order to provide sufficient viability for the DPS; the DPS-level viability criteria allow for some combination of risk status among the component populations. In other words, there is more than one way for an ESU/DPS to meet the viability criteria. The possible combinations of risk status for populations in each MPG that would allow the DPS to meet the viability criteria are called "recovery scenarios."

The ICTRT offered a detailed discussion of possible recovery scenarios for each MPG that would allow the DPS to meet the criteria (ICTRT 2007a). The ICTRT selected these combinations of risk status based on the populations' unique characteristics, such as run timing, population size, or genetics; major production areas in the MPG; and spatial distribution of the populations. Although the ICTRT criteria provide that at least one population in each MPG should reach Highly Viable status, the team did not indicate which population that should be, because of the uncertainties of any population's response to recovery efforts. The ICTRT cautioned against closing off the options for any population prematurely.

> Importantly, although not all populations in an MPG need to meet TRT viability criteria under most viable-MPG scenarios, it is strongly advisable to attempt to improve the status of more than the minimum number of populations to a low risk (viable) situation. There are two primary reasons for this: First, based on current population dynamic theory, the TRT has recommended that all extant populations be maintained with sufficient productivity that the overall MPG productivity does not fall below replacement (i.e. these areas should not serve as significant population sinks). Thus, it would be highly risky to allow the status of any population to degrade. In fact, many populations will need to be improved from their current status to be regarded as "maintained."
>
> Second, although the possible population sets suggested in [the ICTRT's] memo would meet TRT viability criteria for the ESUs, achieving recovery will likely require attempting recovery in more than just those populations because of the uncertainty of success of recovery efforts. A low risk strategy will thus target more populations than the minimum for viability (ICTRT 2007a).

Figure 3-2 shows how the ICTRT applied their MPG-level criteria to the 17 extant populations of the Middle Columbia River Steelhead DPS.

Figure 3-2. Recovery Scenarios: Application of ICTRT Viability Criteria to Middle Columbia River Steelhead MPGs: Options for Viability

MPG & Population	Size Category	Adult Life History Type	Role in Viability Scenario	Considerations
Cascades Eastern Slope MPG: Applying ICTRT viability criteria, for this MPG to be viable, four populations should meet viability criteria, and one should be highly viable.				
Klickitat River	Intermediate	Summer/Winter	Need for Viable status	Only summer/winter population in MPG, and is Intermediate
Fifteenmile Creek	Basic	Winter	Need for Viable status	Only winter population in MPG
Deschutes River East	Intermediate	Summer	Need for Viable status	Only Intermediate summer population
Deschutes River West	Large	Summer	Need for Viable status	Only extant Large population
Rock Creek	Basic	Summer	Maintain	Remaining population
White Salmon (functionally extirpated)	Basic	Summer/Winter		Functionally extirpated, blocked by a dam, abundant hatchery releases of Skamania stock
Crooked River (extirpated)	Very Large	Summer		

MPG & Population	Size Category	Adult Life History Type	Role in Viability Scenario	Considerations
John Day MPG: Applying ICTRT viability criteria, for this MPG to be viable, three populations should meet viability criteria, and one should be highly viable.				
Lower Mainstem John Day	Very Large	Summer	Need for Viable status	Only Very Large population – important for spatial structure because is the most downstream population
N. Fork John Day	Large	Summer	Need for Viable status	Only Large population – good candidate for highly viable because now at low risk. Also important to protect.
Middle Fork John Day	Intermediate	Summer	Option	Need one Intermediate population
Upper Mainstem John Day	Intermediate	Summer	Option	Need one Intermediate population
So. Fork John Day	Basic	Summer	Maintain	Remaining population

MPG & Population	Size Category	Adult Life History Type	Role in Viability Scenario	Considerations
Yakima River MPG: Applying ICTRT viability criteria, for this MPG to be viable, two populations should meet viability criteria, and one should be highly viable. In this case, the two viable populations could be BOTH Naches R. and Yakima Upper Mainstem, OR one of these and Satus Creek.				
Satus Creek	Intermediate	Summer	Option	Only Intermediate population
Naches River	Large	Summer	Option	Need one of two Large populations and one Intermediate OR both Large populations.
Yakima Upper Main	Large	Summer	Option	Need one of two Large populations and one Intermediate OR both Large populations. – This one would be good for spatial structure because it is at the upper end of drainage.
Toppenish Creek	Basic	Summer	Maintain	Remaining population

MPG & Population	Size Category	Adult Life History Type	Role in Viability Scenario	Considerations
Umatilla/Walla Walla MPG: Applying ICTRT viability criteria, for this MPG to be viable, two populations should meet viability criteria, and one should be highly viable.				
Umatilla River	Large	Summer	Need for Viable status	Only Large population
Walla Walla River	Intermediate	Summer	Option	Need one of two Intermediate populations – Walla Walla is now closer to meeting criteria than Touchet
Touchet River	Intermediate	Summer	Option	Need one of two Intermediate populations
Willow Creek (extirpated)	Intermediate	Summer		

3.2 Recovery Goals and Viability Criteria Adopted by Management Unit Plans

The management unit plans include locally determined recovery goals as well as viability criteria for the individual steelhead populations and MPGs in each management unit. All of the management unit plans used the ICTRT viability criteria and worked within the framework of the ICTRT-defined recovery scenarios. In some cases they set higher standards for one or more populations. Most of the plans also provide targets or objectives to measure progress within specified time frames, e.g. 10 to 50 years.

3.2.1 Oregon Steelhead Recovery Plan (Appendix A)

The Oregon Steelhead Recovery Plan for the Oregon portion of the Middle Columbia steelhead DPS states that the plan's primary goal is to support removal of the Middle Columbia Steelhead DPS from the threatened and endangered species list, and that this would require the Middle Columbia steelhead populations and MPGs in Oregon to reach the levels of biological viability defined by the ICTRT (Carmichael 2007).

3.2.1.1 Broad Sense Recovery Goal

The Oregon Steelhead Recovery Plan adds that a further goal, developed in collaboration with the Middle Columbia Sounding Board (described above in Section 1.6.1), is "to rebuild Oregon's Mid-C steelhead populations to levels that will provide for sustainable fisheries and other ecological, cultural, and social benefits . . . [incorporating] many of the traditional uses, as well as rural and Native American values, deemed important in the Pacific Northwest. . . . Recovery of Middle Columbia steelhead populations will require actions that preserve, enhance and restore healthy watershed conditions where ecosystem functions, processes and dynamics are intact ─ including instream conditions, riparian habitat diversity and complexity, and upland watershed health in concert with complementary management of harvest, hatcheries and hydropower. Recovery is a process that leads to steelhead populations that are not only viable, but that also provide a harvestable surplus for the treaty tribes and for all other citizens of the region" (ODFW 2007).

3.2.1.2 Recovery Objectives

The Oregon Steelhead Recovery Plan further states the following recovery objectives, to be achieved by the year 2050[21]:

"1. Middle Columbia steelhead are viable throughout the historical range and no longer need protection under the ESA;
"2. All currently extant Middle Columbia steelhead populations are highly viable;
"3. Extirpated populations (e.g. Willow Creek, Crooked River) are restored in a manner that engages landowner cooperation and does not subject landowners to ESA regulation based on the presence of previously extirpated populations until the introduced populations are self-sustaining and become part of the listed DPS;
"4. All extant populations of Middle Columbia steelhead are capable of contributing ecological, social, cultural, and economic benefits on a regular and sustainable basis;

[21] These objectives are in the Oregon Steelhead Recovery Plan. NMFS is not, by providing them here, committing itself to Oregon's interpretation of the applicability of ESA regulations to reintroduced steelhead in the upper Deschutes River basin, including the Crooked River.

"5. Working in concert with existing agreements and collaboratively with landowners and resource managers NOAA will define a suite of additional land and water resource management principles and practices that when followed will alleviate liability for possible ESA regulatory consequences to landowners and resource managers;
"6. Out-of-basin limiting factors are addressed equitably and in concert with in-basin limiting factors;
"7. Landowners, land managers and agencies are provided with guidance on the protection and management of habitats to promote the recovery of Middle Columbia River steelhead; and,
"8. Land and resource managers work with communities and other interests in a coordinated manner to achieve broad sense recovery through a shared vision of conservation where options and choices are preserved for future generations."

3.2.1.3 Viability Criteria

The Oregon Steelhead Recovery Plan adopts the ICTRT viability criteria for measuring progress toward delisting in terms of the four VSP parameters. Table 3-2 (Table 1-1 in Oregon Steelhead Recovery Plan Executive Summary) shows the minimum threshold abundance levels and minimum productivity required for Oregon Middle Columbia steelhead populations to achieve a 95 percent probability of persistence over 100 years.

Table 3-2. Oregon Mid-C steelhead population characteristics and minimum abundance and productivity values (at the threshold abundance level) needed to achieve a 95 percent probability of persistence over 100 years. (Source: ODFW 2009).

Population	Extant/ Extinct	Life History	Size	Threshold Abundance	Minimum Productivity
Fifteenmile Creek	Extant	Winter	Basic	500	1.56
Deschutes River E.	Extant	Summer	Intermediate	1,000	1.35
Deschutes River W.	Extant	Summer	Large (Inter.)[22]	1,500 (1,000)	1.35
Deschutes/Crooked	Extinct	Summer	Very Large	2,250	1.19
Lower Mainstem John Day R.	Extant	Summer	Very Large	2,250	1.19
North Fork John Day R.	Extant	Summer	Large	1,500	1.26
Middle Fork John Day R.	Extant	Summer	Intermediate	1,000	1.35
South Fork John Day R.	Extant	Summer	Basic	500	1.56
Upper Mainstem John Day R.	Extant	Summer	Intermediate	1,000	1.19
Willow Creek	Extinct	Summer	Intermediate	1,000	1.35
Umatilla River	Extant	Summer	Large	1,500	1.26
Walla Walla River	Extant	Summer	Intermediate	1,000	1.35

3.2.1.4 Recovery Scenario

The Oregon Steelhead Recovery Plan sets a higher standard for Oregon populations than the minimum identified by the ICTRT for DPS viability. Several scenarios or combinations of populations would satisfy the MPG-level viability criteria for the three MPGs containing Oregon Middle Columbia steelhead populations. But the Oregon Steelhead Recovery Plan states that "targeting only the minimum number of populations would likely result in failure to achieve our

[22] Large size category is for historically accessible area; intermediate size category is for currently accessible area.

goals," because of the uncertainty involved in predicting the biological response to management actions intended to aid recovery. "To hedge against this uncertainty, more than the minimum number of populations must be targeted for viable status. Therefore, we also seek to improve other extant Oregon populations to be maintained at sufficient levels to provide for ecological functions and to preserve options for DPS recovery" (ODFW 2009).

The following are the Oregon Steelhead Recovery Plan's delisting recommendations[23] for the three MPGs with Middle Columbia steelhead populations in Oregon:

Cascades Eastern Slope Tributaries MPG
To achieve viable status for this MPG, the Fifteenmile Creek, Deschutes River Eastside, Deschutes River Westside, and Klickitat populations must all achieve viable status. One of these populations must be highly viable. The Rock Creek population must be maintained.

John Day River MPG
To achieve viable status for this MPG, the Lower Mainstem John Day River, North Fork John Day River, and either the Middle Fork John Day River or Upper Mainstem John Day River populations must achieve viable status. One of these populations must be highly viable. The South Fork John Day River population must be maintained.

Umatilla/Walla Walla River MPG
To achieve viable status for this MPG, the Umatilla River population and either the Walla Walla River or Touchet River population must achieve viable status. One of these populations must be highly viable. All remaining extant populations must be maintained.

3.2.2 Washington Gorge Management Unit Plans (Appendices B and C)

The Klickitat River Plan's primary goal is to restore the Klickitat steelhead population to viable status and thus to support recovery of the Middle Columbia steelhead DPS (Appendix B). The Rock Creek Plan's primary goal is to achieve "maintained" status for the Rock Creek population as part of attaining viable status for the Cascades Eastern Slope Tributaries MPG (Appendix C). The White Salmon Plan's goal is to re-establish the White Salmon River population so that it can contribute to the conservation and survival of the DPS.

3.2.2.1 Broad Sense Recovery Goal

If a Washington Gorge Area regional recovery planning organization is created, it would have the option of developing broad sense goals for the area in a collaborative process with diverse stakeholders. In the meantime, the Yakama Nation has proposed, as a broad sense goal for the Klickitat steelhead population, the achievement of "highly viable" status, which corresponds to a one percent risk of extinction in a 100-year period. Achieving highly viable status for the population would provide for long-term, sustainable harvest and other social, cultural, and ceremonial needs, although it would likely exceed the minimum necessary to support delisting the DPS.

[23] The delisting decision is NMFS' responsibility, as described in Section 3.5.

3.2.2.2 Recovery Objectives

At this time NMFS is simply providing proposed ICTRT viability criteria for the Klickitat and Rock Creek populations.

3.2.2.3 Viability Criteria

The Klickitat and Rock Creek plans adopt the ICTRT viability criteria for their respective populations. The White Salmon plan recommends recovering the White Salmon extirpated population to viable status when passage is restored.

Klickitat Subbasin Recovery Plan (Appendix B): The ICTRT-recommended minimum abundance threshold for the Klickitat steelhead population to meet the criterion of a 5 percent or less risk of extinction over a 100-year time frame is 1000 naturally produced spawners at 1.3 spawner/spawner ratio. Regarding spatial structure and diversity, the Plan recommends research on the extent of the impacts of an outside stock (i.e. Skamania stock) hatchery program on natural spawning areas in the subbasin, and reducing these impacts if they are found to be substantial.

Rock Creek Subbasin Recovery Plan (Appendix C): The ICTRT-recommended minimum abundance threshold for the Rock Creek steelhead population to meet the criterion of a 5 percent or less risk of extinction over a 100-year timeframe is 500 naturally produced spawners. The current steelhead range in the Rock Creek watershed is believed to generally resemble the historical condition; therefore, the plan recommends maintaining current spatial structure.

White Salmon Subbasin Recovery Plan (to be included in the Lower Columbia River ESA Recovery Plan): The White Salmon steelhead population was functionally extirpated by the construction of Condit Dam. The dam is scheduled to be removed in 2010. The ICTRT recognizes that recovering this functionally extirpated population to a viable level may not be necessary to achieve viability at the MPG and DPS levels (ICTRT 2007a). When the dam is removed, the Plan recommends that this population eventually be recovered to a minimum abundance threshold of 500 spawners.

3.2.2.4 Recovery Scenario

The Klickitat and Rock Creek plans adopt the ICTRT-recommended scenario for their respective populations, i.e. to achieve viable status for the Klickitat population and maintained status for Rock Creek. The White Salmon plan recommends recovering the White Salmon extirpated population to viable status when passage is restored.

3.2.3 Southeast Washington Plan (Appendix D)

The Snake River Salmon Recovery Board (SRSRB) "defined salmon recovery at two levels: recovery and restoration. Recovery is defined as meeting ESA de-listing requirements based on VSP criteria. The goal of restoration is attainment of conditions that provide increased harvest opportunity for local communities and Tribes, thereby meeting [tribal] trust and treaty rights, as well as fisheries mitigation objectives for mainstem dams."

3.2.3.1 Broad Sense Goal

For the Southeast Washington plan, the equivalent of a broad sense goal is what this plan calls "restoration." Restoration means not simply harvestable levels of steelhead but also "a healthy ecosystem that fulfills the requirements of the key species and the people of the recovery region . . . [with] adequate and appropriate habitat for all salmonid life stages and free access to that habitat." Harvest must be at sustainable levels, hatcheries must contribute to recovery with minimal risk, and hydrosystems must not jeopardize the continued existence of the species.

The plan summarized restoration goals for abundance that were proposed by various agencies and Tribes, which include both naturally produced and hatchery returns (see Table 5-12, SRSRB Plan). Fisheries co-managers and the SRSRB are currently still in discussion regarding these longer-term goals.

3.2.3.2 Recovery Objectives – Planning Targets

The SRSRB set "short-term" (15-year) recovery planning targets for the Walla Walla and Touchet populations of the Walla Walla/Umatilla MPG, based on the ICTRT's viability curves for those populations. Both populations are classified as Intermediate size, and therefore their recovery goal is 1000 spawners each, with 1.35 spawner:spawner ratio.

The management unit plan also established general planning targets for spatial structure and diversity, as follows:

1. Where possible, expand current spawning distributions to match the historical condition as defined by the Major Spawning Areas in each subbasin.
2. Develop populations that are separated spatially so that risks due to catastrophic events are reduced.
3. Increase, insofar as the historical patterns can be reconstructed, the similarity between current and historical patterns of juvenile rearing distribution, habitat usage, and life history types.

The SRSRB plan also sets specific targets for habitat improvements, including criteria for such factors as large woody debris, riparian condition, water temperature, and channel confinement (Chapter 7, SRSRB Plan).

3.2.3.3 Viability Criteria

The SRSRB Plan used the ICTRT viability curves for each population to determine abundance and productivity values needed for delisting and also to identify the values needed for restoration of the populations under improved habitat conditions.

3.2.3.4 Recovery Scenario

The Southeast Washington Plan accepts the ICTRT recovery criteria and thus supports the scenario shown in Figure 3-1, which indicates that either the Walla Walla or Touchet Middle Columbia steelhead population should reach viable status for delisting. However, the SRSRB's long-term restoration goal is to achieve a healthy ecosystem that supports viability for both steelhead populations.

3.2.4 Yakima Steelhead Recovery Plan (Appendix E)

The Yakima Steelhead Recovery Plan was submitted to NMFS by the YBFWRB to address recovery issues for the Yakima MPG of Middle Columbia steelhead (see Section 1.6.4). This plan states that its "overall goal . . . is to ensure long-term persistence of viable populations of naturally produced steelhead distributed across their native range."

3.2.4.1 Broad Sense Recovery Goal

The Yakima Steelhead Recovery Plan sets a long-term, or broad sense, recovery goal to increase the abundance and productivity of Yakima Basin steelhead populations to levels that allow for harvest for recreational, commercial, and ceremonial purposes. This goal is articulated in the YBFWRB's Vision 2020 statement (Section 1.2 of the Yakima Steelhead Recovery Plan), which describes, in general terms, desired future conditions for the Yakima basin:

> *Yakima River basin communities have restored the Yakima River basin sufficiently to support self-sustaining and harvestable populations of indigenous fish and wildlife while enhancing the existing customs, cultures, and economies in the basin. Decisions that continuously improve the river basin ecosystem are made in an open and cooperative process that respects different points of view and varied statutory responsibilities and benefits current and future generations.*

3.2.4.2 Recovery Objectives/Scenarios

The Yakima Steelhead Recovery Plan defines three "thresholds" for assessing progress toward recovery: thresholds for ESA delisting, short-term recovery, and long-term (broad sense) recovery. As used in the Yakima Steelhead Recovery Plan, "threshold" combines two concepts that are differentiated in this DPS plan, i.e. recovery objectives and recovery scenario. The YBFWRB sees these three thresholds as points on a continuum and expects recovery actions to continue after delisting, even without the immediate motivation of the ESA. The long-term goals are less definite, but are meant to affirm that the Board and its partners believe that long-term recovery to significantly higher abundance levels is both feasible and desirable.

The delisting threshold is based on the ICTRT's MPG viability criteria: one population should be viable, one highly viable, and two should be at "maintained" status or better. The YBFWRB expected that the Satus population would be most likely to achieve "highly viable" status, the Naches population "viable," and the Toppenish and Upper Yakima populations "maintained."

The short-term recovery threshold also is based on the ICTRT criteria, but with continuing recovery actions, all four populations would be expected to achieve viable status. This would significantly reduce overall risk to the MPG.

The long-term recovery threshold is, as described above, a stable, long-term condition in which wild steelhead in the Yakima Basin are thriving and harvestable, based on restored access to as many of the historically accessible stream reaches as is consistent with the Board's commitment to sustaining local customs and economies.

3.2.4.3 Viability Criteria

The Yakima Steelhead Recovery Plan defines abundance and productivity criteria for the delisting, short-term, and long-term thresholds in terms of the ICTRT's viability criteria, as shown in Table 3-3.

Table 3-3 Yakima Steelhead Populations Abundance and Productivity Criteria (Source: Executive Summary, Yakima Steelhead Recovery Plan).

	Delisting Threshold		Short-Term Recovery		Long-term Recovery	
Population	**Avg. #**	**Prod.**	**Avg. #**	**Prod.**	**Avg. #**	**Prod.**
Satus: Satus Watershed[24] Mainstem Block	 500 500	 2.00[25] 1.65	 500 500	 1.56 1.56	 2,000	 1.2 1.2
Toppenish	250	1.2	500	1.56	1,500	1.2
Naches	1,500	1.26	1,500	1.26	5,400	1.2
Upper Yakima	500	1.2	1,500	1.26	7,700	1.2
Total	***3,250***		***4,500***		***16,600***	

The Yakima Steelhead Recovery Plan presents spatial structure and diversity criteria for the four Yakima steelhead populations. The spatial structure criteria are more complex, since several important historical spawning areas are either no longer accessible to steelhead or no longer feasible for spawning.

Satus
Naturally produced steelhead will occupy both major spawning areas in the Satus watershed (Satus and Dry Creek MSAs) and the Mule Dry minor spawning areas. Consistent spawning must occur in both major spawning areas.

Toppenish
Naturally produced steelhead will occupy both of the major spawning areas in the Toppenish watershed (upper Toppenish and Simcoe). Consistent spawning must occur in both major spawning areas.

Naches
Naturally produced steelhead will occupy at least seven of the eight major spawning areas for the delisting and short-term recovery thresholds. For the long-term recovery threshold, all eight will

[24] For its historical population analysis, the ICTRT included the mainstem Yakima habitat below the confluence of Satus Creek in the Satus Creek population, and therefore classified the Satus population as Intermediate in size. However, if the potential mainstem component is lumped instead with mainstem Yakima River habitat upstream of Satus, the population in the Satus Creek watershed alone would be Basic size. The Yakima plan discusses this question in more detail in Section 4.1.1.

[25] The Yakima Steelhead Recovery Plan calls for managing the Satus population in two blocks: the tributary block treated as a Basic population with the goal of high viability and the mainstem block treated with a simple abundance target that can be met within that portion of the mainstem Yakima or by additional production above and beyond the abundance targets for other areas.

be occupied. Consistent spawning must occur within the Naches mainstem, Ahtanum Creek, and Rattlesnake Creek to maintain distribution across habitat types and life histories.

Upper Yakima
Naturally produced steelhead will occupy at least 10 of the 14 major spawning areas for the delisting and short-term recovery thresholds. For the long-term recovery threshold, 12 of 14 MSAs will be occupied. Spawning must consistently occur within at least the Yakima mainstem, Umtanum Creek, Swauk Creek, Manashtash Creek, Taneum Creek and the Teanaway River (West and North Teanaway MSA and Lower Teanaway minor spawning area). While passage at Cle Elum, Kachess and/or Keechelus Dams is not specifically required to meet this threshold, providing passage can play an important role.

The diversity goal for all thresholds is to maintain and enhance both phenotypic (morphology, behavior, and life history traits) and genotypic diversity while limiting introgression of non-local genes.

3.3 Listing Factors/Threats Criteria

Listing factors are those features that are evaluated under section 4(a)(1) when initial determinations are made whether to list species for protection under the ESA. "Threats," in the context of salmon recovery, are understood as the activities or processes that cause the biological and physical conditions that limit salmon survival (the limiting factors). "Threats" also refer directly to the listing factors detailed in section 4(a)(1) of the ESA.

ESA section 4(a)(1) listing factors are the following:

A. Present or threatened destruction, modification, or curtailment of [the species'] habitat or range;
B. Over-utilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. Inadequacy of existing regulatory mechanisms; or
E. Other natural or human-made factors affecting [the species'] continued existence.

At the time of a delisting decision for the Middle Columbia steelhead, NMFS will examine whether the section 4(a)(1) listing factors have been addressed. To assist in this examination, NMFS will use the listing factors (or threats) criteria described below, in addition to evaluation of biological recovery criteria and other relevant data and policy considerations. The threats need to have been addressed to the point that delisting is not likely to result in their re-emergence. It is possible that currently perceived threats will become insignificant in the future due to changes in the natural environment or changes in the way threats affect the entire life cycle of salmon. Consequently, NMFS expects that the relative priority of threats will change over time and that new threats may be identified. During the 5-year reviews, NMFS may review the listing factor criteria as they apply at that time.

The specific criteria listed below for each of the relevant listing/delisting factors help to ensure that underlying causes of decline have been addressed and mitigated before a species is considered for delisting. NMFS expects that if the proposed actions described in the Plan are

implemented, they will make substantial progress toward meeting the following listing factor (threats) criteria for the Middle Columbia steelhead.

While NMFS appreciates that regional managers would like to have clear, more specifically defined targets for reducing threats, and accordingly a clear path to delisting, many scientific uncertainties remain. Building adaptive management into the recovery plan is an appropriate response to these uncertainties. Research, monitoring, and evaluation (RM&E) are necessary for adaptive management. The threats criteria listed in this section for each of the relevant listing/delisting factors are intended to help recovery planners formulate appropriate RM&E to ensure that underlying causes of decline have been addressed and mitigated before a species is considered for delisting. NMFS expects the appropriate metrics to be developed in the cooperative process of local and regional implementation, then fed back into adaptive management for steelhead recovery. In some cases, metrics or targets in certain categories have already been established by NMFS or by management unit planners and approved by NMFS. These will become part of the RM&E plan that will be developed after the DPS plan has been approved (see Chapter 10 of this Plan).

Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range

To determine that the DPS is recovered, threats to habitat should be addressed as outlined below:

1. Passage obstructions (e.g., dams and culverts) are removed or modified to improve survival and restore access to historically accessible habitat where necessary to support recovery goals.

2. Flow conditions that support adequate rearing, spawning, and migration are achieved through management of mainstem and tributary irrigation and hydropower operations, and through increased efficiency and conservation in other consumptive water uses such as municipal supply.

3. Sufficient instream flows are protected to provide for steelhead in appropriate life stages.

4. Forest management practices that protect watershed and stream functions are implemented on Federal, state, tribal, and private lands.

5. Agricultural practices, including grazing, are managed in a manner that protects and restores riparian areas, floodplains, and stream channels, and protects water quality from sediment, pesticide, herbicide, and fertilizer runoff.

6. Urban and rural development, including land use conversion from agriculture and forestland to residential uses, does not reduce water quality or quantity, or impair natural stream conditions so as to impede achieving recovery goals.

7. The effects of toxic contaminants on salmonid fitness and survival are sufficiently limited so as not to affect recovery.

8. Channel function, including vegetated riparian areas, canopy cover, stream-bank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity are restored to provide adequate rearing and spawning habitat.

9. Floodplain function and the availability of floodplain habitats for salmon are restored to a degree sufficient to support a viable DPS. This restoration should include connectedness between river and floodplain and the restoration of impaired sediment delivery processes.

Factor B: Over-utilization for commercial, recreational, scientific or educational purposes

To determine that the DPS is recovered, any utilization for commercial, recreational, scientific, or educational purposes should be managed as outlined below:

1. Fishery management plans for steelhead are in place that (a) accurately account for total fishery mortality (i.e., both landed catch and non-landed mortalities) and constrain mortality rates to levels that are consistent with recovery; and (b) are implemented in such a way as to avoid deleterious genetic effects on populations or negative effects on the distribution of populations.

2. Federal, tribal and state rules and regulations are effectively enforced.

3. Technical tools accurately assess the effects of the harvest regimes so that harvest objectives are met but not exceeded.

4. Handling of fish is minimized to reduce indirect mortalities associated with educational or scientific programs, while recognizing that monitoring, research, and education are key actions for conservation of the species.

5. Routine construction and maintenance practices are managed to reduce or eliminate mortality of listed species.

Factor C: Disease or predation

To determine that the DPS is recovered, any disease or predation that threatens its continued existence should be addressed as outlined below:

1. Hatchery operations do not subject targeted populations to deleterious diseases and parasites and do not result in increased predation rates of wild fish.

2. Predation by avian predators is managed in a way that allows for recovery of salmon and steelhead populations.

3. The northern pikeminnow is managed to reduce predation on the targeted populations.

4. Populations of introduced exotic predators such as smallmouth bass, walleye and catfish are managed such that competition or predation does not impede recovery.

5. Predation of winter steelhead runs below Bonneville Dam by marine mammals does not impede achieving recovery.

6. Physiological stress and physical injury that may cause disease or increase susceptibility to pathogens during rearing or migration is reduced during critical low flow periods (e.g. low water years) or poor passage conditions (e.g. at diversion dams or bypasses).

Factor D: The inadequacy of existing regulatory mechanisms

To determine that the DPS is recovered, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be addressed as outlined below:

1. Adequate resources, priorities, regulatory frameworks, and coordination mechanisms are established and/or maintained for effective enforcement of land and water use regulations that protect and restore habitats, including water quality and water quantity, and for the effective management of fisheries.
2. Habitat conditions and watershed functions are protected through land-use planning that guides human population growth and development.
3. Habitat conditions and watershed function are protected through regulations that govern resource extraction such as timber harvest and gravel mining.
4. Habitat conditions and watershed functions are protected through land protection agreements as appropriate, where existing policy or regulations do not provide adequate protection.
5. Regulatory, control, and education measures to prevent additional exotic plant and animal species invasions are in place.
6. Sufficient priority instream water rights for fish habitat are in place.

Factor E: Other natural or human-made factors affecting [the species'] continued existence

To determine that the DPS is recovered, other natural and man-made threats to its continued existence should be addressed as outlined below:

1. Hatchery programs are being operated in a manner that is consistent with individual watershed and region-wide recovery approaches; appropriate criteria are being used for integration of hatchery steelhead populations and extant natural populations inhabiting watersheds where the hatchery fish return.
2. Hatcheries operate using appropriate ecological, genetic, and demographic risk containment measures for (1) hatchery-origin adults returning to natural spawning areas, (2) release of hatchery juveniles, (3) handling of natural-origin adults at hatchery facilities, (4) withdrawal of water for hatchery use, (5) discharge of hatchery effluent, and (6) maintenance of fish health during their propagation in the hatchery.
3. Monitoring and Evaluation plans are implemented to measure population status, hatchery effectiveness, and ecological, genetic, and demographic risk containment measures.
4. Nutrient enrichment programs are implemented where it is determined that nutrient limitations are a significant limiting factor for steelhead production and that nutrient enrichment will not impair water quality.

3.4 Delisting Decision

NMFS concludes that the biological viability criteria as described in Sections 3.1 and 3.2, and the listing factor (threats) criteria (described in Section 3.3), define conditions that, when met, would result in a determination that the Middle Columbia steelhead DPS is not likely to become endangered within the foreseeable future throughout all or a significant portion of its range. These criteria could exceed the minimum necessary to delist the DPS.

In accordance with our responsibilities under section 4(c)(2) of the ESA, NMFS will conduct reviews of Middle Columbia steelhead every five years to evaluate the status of the DPS and determine whether it should be removed from the list or changed in status. Such evaluations will take into account the following:

- The biological recovery criteria (ICTRT 2007a) and listing factor (threats) criteria described above.
- The management programs in place to address the threats.
- Principles presented in the Viable Salmonid Populations paper (McElhany et al. 2000).
- Best available information on population and DPS status and new advances in risk evaluation methodologies.
- Other considerations, including: the number and status of extant spawning groups; the status of the major spawning groups; linkages and connectivity among groups; the diversity of life history and phenotypes expressed; and considerations regarding catastrophic risk.

4. CURRENT STATUS ASSESSMENT OF DPS

ICTRT scientists have aggregated a description of current Middle Columbia steelhead DPS status from information on the status of the component populations, using the VSP parameters of abundance, productivity, spatial structure, and diversity. Several related research reports from the ICTRT, including the most recent status assessment, are available on the Northwest Fisheries Science Center website, http://www.nwfsc.noaa.gov/trt/trt_columbia.cfm.

4.1 ICTRT Status Assessment of Middle Columbia Steelhead DPS

The status of a salmonid ESU or DPS is expressed in terms of likelihood of persistence over 100 years, or in terms of risk of extinction within 100 years. The ICTRT defines viability at two levels: less than 5 percent risk of extinction within 100 years (viable) and less than 1 percent risk of extinction within 100 years (highly viable). A third category, "maintained," represents a less than 25 percent risk. The risk level of the DPS is built up from the aggregate risk levels of the populations and MPGs. All four VSP parameters must be taken into account to determine the risk level.

Table 4-1 summarizes current status of the Middle Columbia steelhead populations, showing 10-year geometric mean abundance by population, estimated productivity (using a 20-year geometric mean), and the minimum abundance threshold needed for long-term viability. The table also includes the 10-year geometric mean proportion of hatchery spawners for the populations where data are available, and the risk ratings of high, moderate, low, and very low, for abundance and productivity combined, and spatial structure and diversity combined. In this chapter, two other ways of representing these findings are presented: graphs called "viability curves" showing the relationship of current abundance and productivity to that required for viability, and a matrix combining all four parameters to illustrate the overall risk rating of each population.

4.2 Viability Curves

The ICTRT developed viability criteria expressed as graphs showing the relationship between abundance and productivity. The result is a curve, called a "viability curve," running from high abundance/low productivity to high productivity/low abundance. The ICTRT then developed a method for adapting viability curves to population size categories, which, as described in Section 3.1.3, are based on estimated intrinsic production potential or capacity of the habitat. The actual current abundance and productivity are then plotted against this viability curve. Populations above the 5 percent risk curve are considered to have a low risk of extinction and below the 5 percent risk curve a higher risk of extinction.

Viability curves for Basic, Intermediate, Large, and Very Large Middle Columbia steelhead populations are depicted below in Figures 4-1 through 4-4, respectively. Only the Deschutes River East and Walla Walla populations (Intermediate) in Figure 4-2 and the North Fork John Day population (Large) in Figure 4-3 meet or exceed the 5 percent minimum risk of extinction in 100 years needed to meet the ICTRT viability criteria. The ovals about the point estimates of actual abundance and productivity represent one standard error of uncertainty about the points.

Table 4-1. Middle Columbia River steelhead DPS populations: summary of abundance, productivity, risk ratings, and minimum abundance thresholds (Source: ICTRT 2007a and 2008). (Numbers subject to periodic updates as additional information becomes available.)

Population	*Abundance Threshold*[26]	*Size Category*	*Run Timing*	*10-year Geomean abundance*	*Abundance Range*	*10-yr Hatchery Fraction*[27]	*Produc-tivity*[28]	*Productivity Standard Error*	*A&P Risk*[29] *Rating*	*SS/D Risk Rating*
Cascades East Slope MPG										
Deschutes (Westside)	1000[30]	Large (Inter)	Summer	456	108-1283	0.26	1.05	0.15	H	M
Deschutes (Eastside)	1000	Intermed.	Summer	1599	299-8274	0.39	1.89	0.27	L	M
Klickitat River	1000	Intermed.	Wtr & Smr	Insufficient data					M	M
Fifteenmile Creek	500	Basic	Winter	703	231-1922	0	1.82	0.20	L	L
Rock Creek	500	Basic	Summer	Insufficient data					H	M
White Salmon	500	Basic		Functionally extirpated					N/A	N/A
Crooked River	2250	Very Large	Summer	Extirpated						
Yakima River MPG										
Upper Yakima River	1500	Large	Summer	85	34-283	0.02	1.12	0.22	H	H
Naches River	1500	Large	Summer	472	142-1454	0.06	1.12	0.22	H	M
Toppenish River	500	Basic	Summer	322	44-1252	0.06	1.60	0.30	M	M
Satus Creek (trib only)	1000	Intermed.	Summer	379	138-1000	0.06	1.73	0.14	M	M
John Day River MPG										
Lower Mainstem John Day	2250	Very Large	Summer	1800	563-6257	0.1	2.99	0.24	M	M
North Fork John Day	1500	Large	Summer	1740	369-10,235	0.08	2.41	0.22	VL	L
Upper Mainstem John Day	1000	Intermed.	Summer	524	185-5169	0.08	2.14	0.33	M	M
Middle Fork John Day	1000	Intermed.	Summer	756	195-3538	0.08	2.45	0.16	M	M
South Fork John Day	500	Basic	Summer	259	76-2729	0.08	2.06	0.27	M	M
Umatilla/Walla Walla MPG										
Umatilla River	1500	Large	Summer	1472	592-3542	0.36	1.50	0.15	M	M
Walla Walla Mainstem	1000	Intermed.	Summer	650	270-1746	0.02	1.34	0.12	M	M
Touchet River	1000	Intermed.	Summer	Insufficient data					H	M
Willow Creek	1000	Intermed.	Summer	Extirpated					N/A	N/A

[26] Abundance threshold for viability based on habitat intrinsic potential
[27] Average proportion of hatchery spawners over most recent 10 years in the data series.
[28] Geomean return per spawner calculated over most recent 20 years in data series.
[29] H = high risk, M= moderate risk, L = low risk, VL = very low risk
[30] The Deschutes Westside steelhead population is classified as Large in terms of spatial structure, but its abundance threshold may be considered 1000 or 1500 because of "currently accessible area" considerations.
See ODFW 2009.

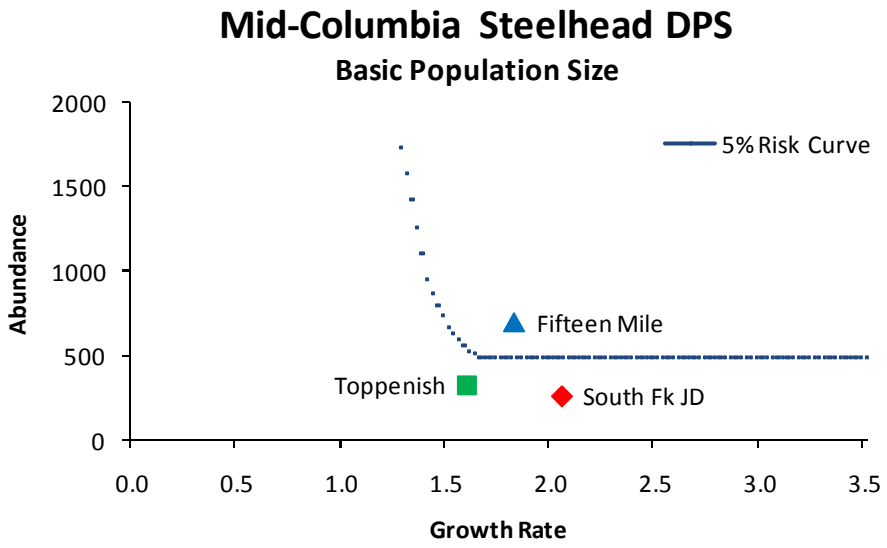


Figure 4-1. Middle Columbia River Steelhead Basic Populations (based on ICTRT 2008).

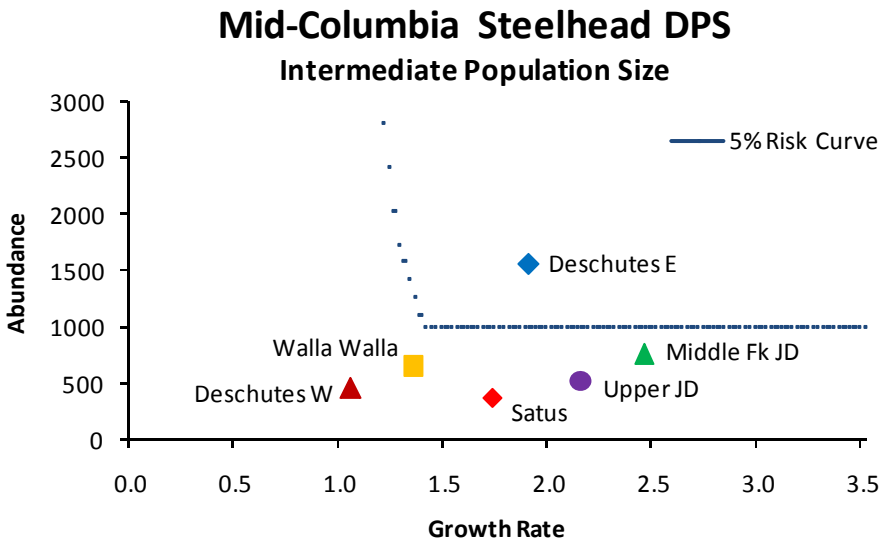


Figure 4-2. Middle Columbia River Steelhead Intermediate Populations (based on ICTRT 2008).

Note: The Deschutes Westside steelhead population is classified as Large in terms of spatial structure, but its abundance threshold may be considered 1000 or 1500 because of "currently accessible area" considerations. See ODFW 2009.

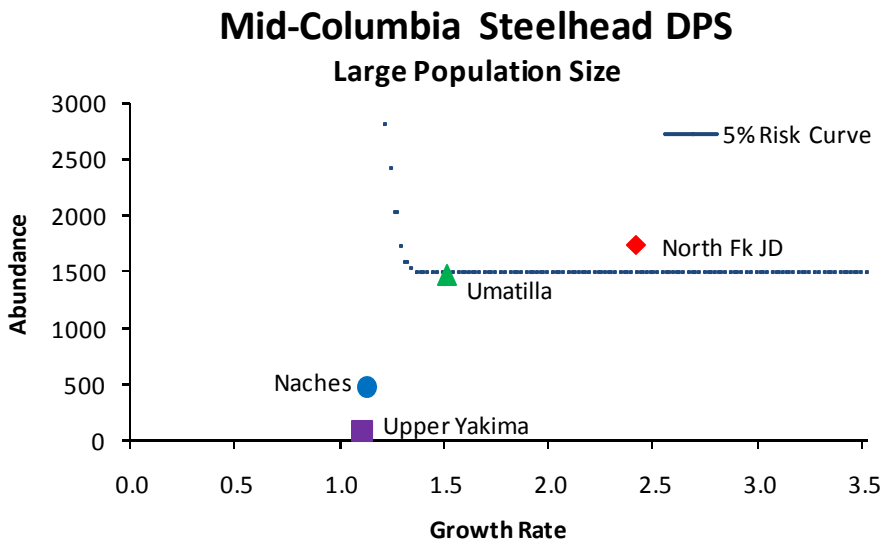


Figure 4-3. Middle Columbia River Steelhead Large Populations (based on ICTRT 2008).

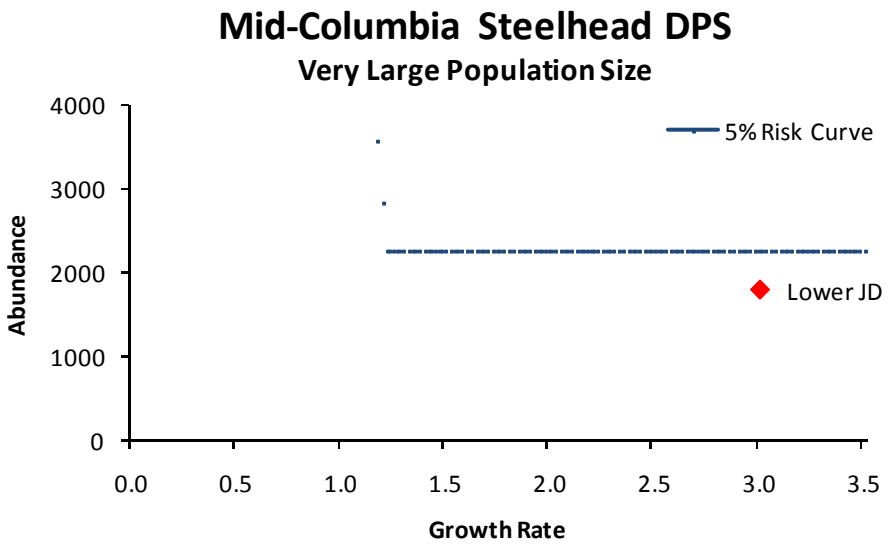


Figure 4-4. Middle Columbia River Steelhead Very Large Populations (based on ICTRT 2008).

4.3 Spatial Structure and Diversity

Although the Middle Columbia steelhead spawning range currently extends over an area of approximately 35,000 square miles, the viability of the DPS with regard to spatial structure and diversity (SS/D) depends on the spatial structure and diversity of each population. Given that one population is extinct and two functionally extirpated, and considering the status of the 17 extant populations, NMFS considers the DPS to be at moderate risk with regard to spatial structure and

diversity. NMFS considers only the Fifteenmile Creek and North Fork John Day populations to be at low SS/D risk. The Upper Yakima River is at high SS/D risk, and the 15 other populations are rated at moderate risk.

The ICTRT examined the steelhead's SS/D risk in terms of biological or ecological "goals," mechanisms that achieve those goals, and factors that influence the mechanisms. They identified two primary goals:

A. *Maintain natural rates and levels of spatially mediated processes*. Spatially mediated processes are, for example, population changes that result from local events such as landslides or other local catastrophes; recolonization within or between populations after such events; or "straying" of spawners away from home streams.

B. *Maintain natural patterns of variation*. Variation in the population – whether it is genetic, behavioral, or a matter of appearance or life history -- helps to ensure that populations can withstand environmental variation in both the short and long term.

The ICTRT defined *mechanisms* as biological or ecological processes that contribute to achieving the *goals*. For example, gene flow patterns are mechanisms that affect the distribution of genotypic and phenotypic variation in a population. *Factors* are characteristics of a population or its environment that influence mechanisms. For example, gaps in spawning distribution affect patterns of gene flow, which then affect patterns of genotypic and phenotypic variation.

In some cases the same factor can affect more than one mechanism or goal. The distribution of spawning areas, for example, can affect both patterns of gene flow and the patterns of spatially mediated processes such as catastrophes.

The ICTRT developed a method for scoring SS/D risk that considers these goals, mechanisms and factors. For example, maintaining natural patterns of gene flow is a mechanism that serves the goal of maintaining natural patterns of variation. The most relevant factor for maintaining natural patterns of gene flow is spawner composition. A high proportion of hatchery fish spawning naturally among wild fish can be a risk factor affecting genetic diversity, depending on the origin of the hatchery fish and other characteristics.

Using metrics and criteria developed for SS/D, the ICTRT scored the Mid-Columbia steelhead populations as shown in Table 4-1. The following is a narrative summary of the SS/D ratings for all four steelhead MPGs.

Cascades Eastern Slope MPG

Of the five extant populations in the Cascades Eastern Slope MPG, NMFS considers only the Fifteenmile Creek population to be at low risk of extinction with regard to spatial structure and diversity. The ICTRT rated the Klickitat River, Deschutes Eastside, and Deschutes Westside populations at moderate SS/D risk: these three have low risk for natural processes but moderate risk for diversity, because of the potential influence of naturally spawning, out-of-DPS hatchery fish. The Rock Creek population is assigned moderate SS/D risk, with the caution that more data are needed (ICTRT 2008).

John Day MPG

In the John Day MPG, only the North Fork John Day population has a low SS/D risk. The high proportion of out-of-population or out-of-DPS spawners puts the Middle and South Fork John Day populations at moderate risk. The high proportion of strays is a potential problem for all the John Day populations (ICTRT 2008).

All five populations in this group spawn across the historical range of tributary habitats and are rated at low or very low risk for spatial structure, or Goal A, maintaining natural rates and levels of spatially mediated processes (ICTRT 2008). The Lower Mainstem and Upper Mainstem populations are rated at moderate risk for life history diversity because of limitations and reductions in particular juvenile rearing time and area pathways, inferred from current temperature and flow conditions in the tributaries, the mainstem John Day River, and the mainstem Columbia River (ICTRT 2008). In addition, the Lower Mainstem John Day River population was rated at moderate risk for genetic diversity. Sport fishery and spawning ground sampling information indicates that a relatively high proportion of out-of-basin hatchery fish may be contributing to spawning, but no direct genetic sampling data are available.

In the Oregon Steelhead Recovery Plan, the Middle Fork and South Fork John Day populations are shown as having Low SS/D risk. The difference turns on the weight given in the integrated SS/D rating to the high proportion of out-of-population or out-of-DPS strays spawning naturally in these areas. The ICTRT rates both populations as at high risk for diversity, and therefore, overall moderate SS/D risk. The Oregon Conservation Plan rates the overall risk as low, "with the exception" of spawner composition.

Yakima River MPG

Three of the Yakima River steelhead populations are rated at moderate SS/D risk, and one, the Upper Yakima River, at high risk (ICTRT 2008). The SS/D risk for the Satus Creek, Toppenish Creek, and Naches River populations is moderate, because of changes related to Goal B – maintaining natural patterns of variation. These include changes in life history strategies – spawning, rearing, and migration timing – as well as changes in phenotypic or genetic traits, related to altered habitat, particularly flow regimes and water temperature. For the Satus Creek, Toppenish Creek, and Naches River populations, there are also changes in the distribution of spawning. The Upper Yakima River is at high risk for spatial structure and diversity because of loss of spawning areas, decreased life history variation, and possible genetic introgression with planted rainbow trout. All of these populations must pass four major dams in the mainstem Columbia River, and the ICTRT notes that characteristics of the hydropower system create selective pressures on various traits such as size and adult and juvenile migration timing, reducing variations that were likely present historically.

Umatilla/Walla Walla MPG

The ICTRT rated all three populations in the Umatilla/Walla Walla MPG as at moderate risk (ICTRT 2008). All three have lost spawning habitat, and the distances between occupied areas have increased. Phenotypic changes such as reduced variation in adult and juvenile migration patterns are inferred from changes in flow patterns and water temperature. For the Umatilla River, a high proportion of hatchery-origin fish spawning naturally represents a diversity risk.

For the Walla Walla River, a moderate risk is attributed to out-of-DPS strays spawning naturally. Water temperature and hydrograph changes as well as passage barriers have likely influenced life history diversity and phenotypic expression (ICTRT 2008). The Touchet population has good spatial distribution but was given a moderate risk rating because of assumed or inferred loss of life history and phenotypic variation. The ICTRT emphasized the need for more data for the Touchet (ICTRT 2008).

4.4 Population-Level Risk Rating

Given the hierarchical structure of salmonid biology (see Section 2.2, above), an overall assessment of risk of extinction for an ESU or DPS must be built up from assessments of risk for the component populations and then the MPGs.

The ICTRT integrated all four VSP parameters in a simple matrix (Figure 4-5). One side of the matrix is a series of risk levels for the combined abundance and productivity parameters (A/P): very low risk, i.e. less than a 1 percent risk of extinction within 100 years; low risk, less than a 5 percent risk of extinction within 100 years; moderate risk, less than a 25 percent risk of extinction within 100 years; and high risk, more than a 25 percent risk of extinction within 100 years. The A/P rating for each population is taken from the corresponding viability curve (see Section 4.2 above). A viable population is considered to have no more than a 5 percent A/P risk.

Across the top of the matrix is a series of risk levels for spatial structure and diversity (SS/D). The range of viable combinations of A/P and SS/D risks for a population can be seen in the top two rows combined with the first three columns. Populations with a Very Low risk rating for A/P and at least a Low rating for SS/D are considered to be "Highly Viable." Populations with a Low risk rating for A/P and a Moderate rating for SS/D are considered to be "Viable." Populations that fall into the cells outside this range cannot be considered viable by the standard set forth in the VSP paper (McElhany et al., 2000) and used by all of the TRTs. These individual scores are integrated to determine the viability of MPGs (ICTRT 2005), and the assessments of the component MPGs are aggregated to assess the DPS as a whole. The ICTRT used this approach to examine the viability of independent steelhead populations in the Middle Columbia DPS.

In Figure 4-5, five of the cells at higher risk are labeled "Candidate for maintained status." The ICTRT recognizes that some populations may not need to be fully viable to make the DPS viable, and yet maintaining them at some level will provide ecological functions and preserve options for DPS recovery. As a rule of thumb, populations that fall within cells adjacent to those regarded as viable in the risk matrix (Figure 4-5 in this recovery plan) can be regarded as "maintained."

The ICTRT (2007a) details how maintained populations contribute to the ecological functioning of the DPS and preserve recovery options in the event that efforts to recover other populations to viable levels fail.

Having populations meet maintained standards:

- Provides a hedge against the potential risk that the cumulative productivity across populations within an MPG may fall below replacement.
- Provides insurance against catastrophic events. For example, if a catastrophe impacts one or more of the functioning viable populations within the MPG, the other populations will

need to be at sufficient levels so that they can replenish those populations lost to or affected by the catastrophe.

- Allows these populations to serve as genetic or demographic "stepping stones" between populations, allowing natural patterns of gene flow and dispersal.
- Provides a buffer against uncertainty in the ICTRT population and MPG criteria. For example, having populations meet maintained standards preserves recovery options in the event that efforts to recover other populations to viable levels fail.

Although populations with specific combinations of A/P and SS/D ratings are candidates for Maintained status (Figure 4-5), the ICTRT cautions that it is difficult to capture all of the necessary attributes to meet the objectives for maintained populations in a simple set of integrated A/P and SS/D risk ratings. For each MPG, candidate populations should be reviewed individually and in context with the other populations against the above principles.

> "In general, populations with moderate abundance and productivity risk levels near 25% with high year-to-year variability or populations with high risk for multiple SS/D factors are less likely to be considered Maintained. A primary consideration in setting an abundance objective [for a] population in the smallest size category (Basic) would be uncertainty in current estimates of abundance and productivity. Given the levels of uncertainty in estimating recent geomean abundance and productivity, the abundance objectives for Basic populations should exceed 250 spawners [if they are] to be designated as Maintained status. Populations classified in any of the three largest size categories should be at abundance levels not less than 500, and will likely require average abundance levels approaching minimum threshold values to address demographic and genetic considerations." (ICTRT 2007a)

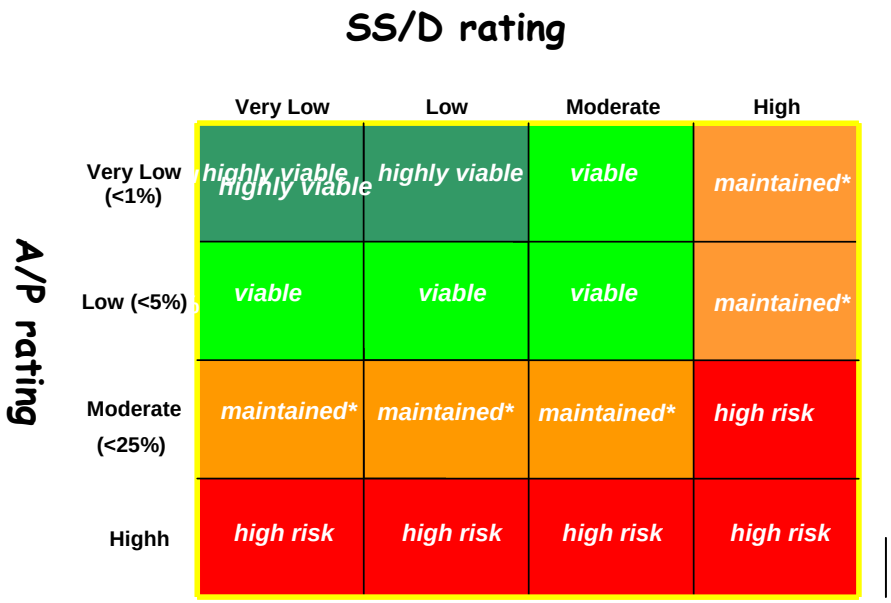


Figure 4-5. Assessing Population Viability Across VSP Criteria (ICTRT 2005).
***** Candidate for maintained status

4.5 Current Population Status

According to the ICTRT viability criteria, the majority of natural Middle Columbia steelhead populations are rated at moderate risk for abundance and productivity, but low to moderate risk for spatial structure and diversity (Table 4-1, Figure 4-6, and Figure 4-7). This DPS includes one highly viable population (North Fork John Day), two viable (Fifteenmile Creek and Deschutes River Eastside), five at high risk of extinction within 100 years (Deschutes Westside, Upper Yakima Mainstem, Naches River, Rock Creek, and Touchet[31]), and the remaining nine at moderate risk.

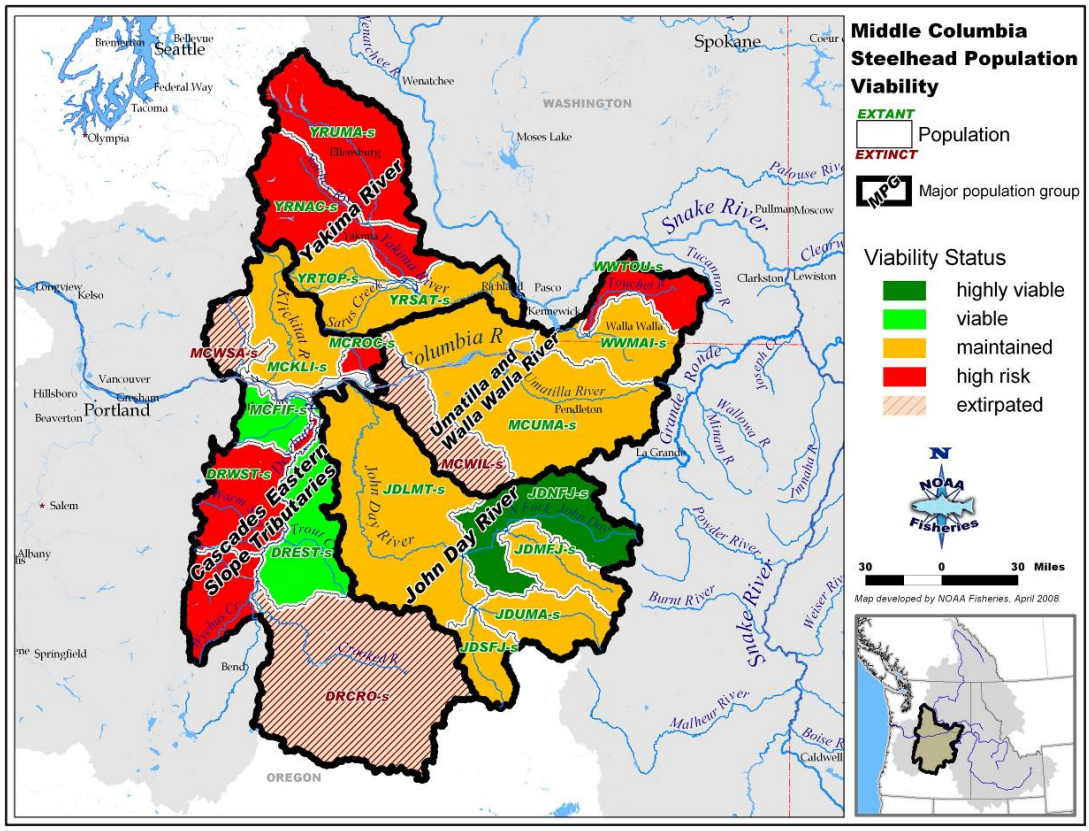


Figure 4-6. Middle Columbia Steelhead Population Viability (ICTRT, May 2008).

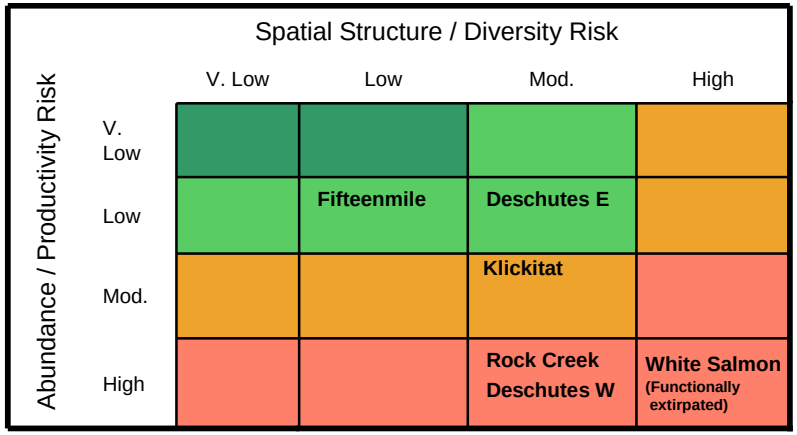
4.6 MPG Status

The ICTRT's viability ratings of the component populations of each Middle Columbia steelhead MPG are shown in the matrices below (Figure 4-7). None of the MPGs as a whole reaches low risk status according to the ICTRT's MPG-level criteria (shown in Figure 3-2).

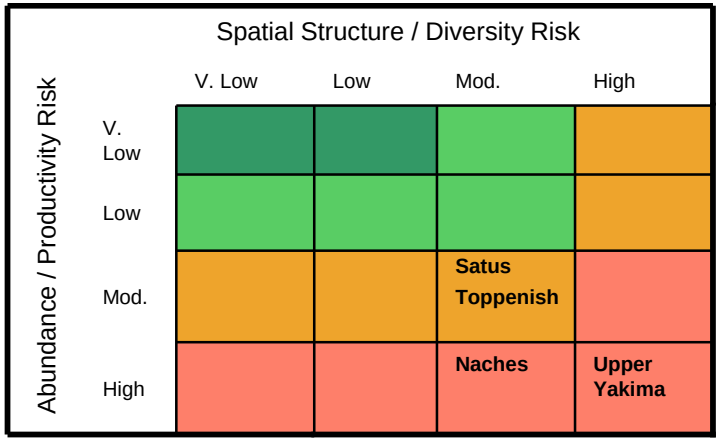
4.7 DPS Status

The ICTRT's ESU-level viability criterion is the following: All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU should be at low risk (ICTRT 2007a). Thus, the Middle Columbia steelhead DPS does not currently meet viability criteria based on the determination that the four component MPGs are not at low risk.

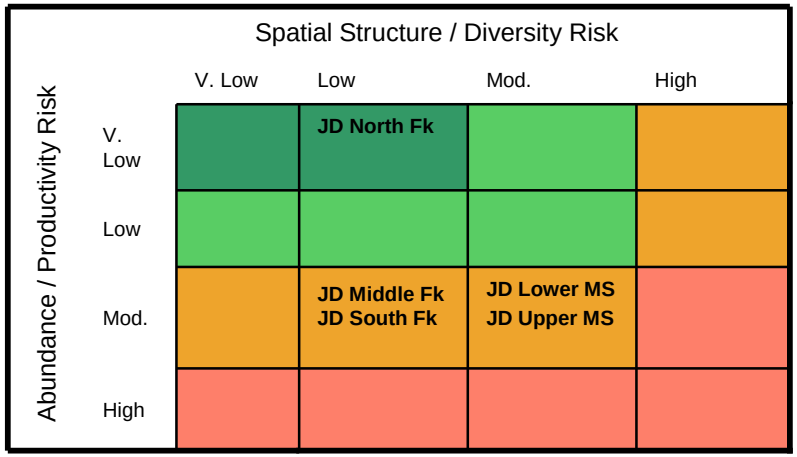
[31] The Rock Creek and Touchet populations are rated at High Risk because of uncertainty resulting from the limited set of annual return estimates (with significant missing years) currently available.



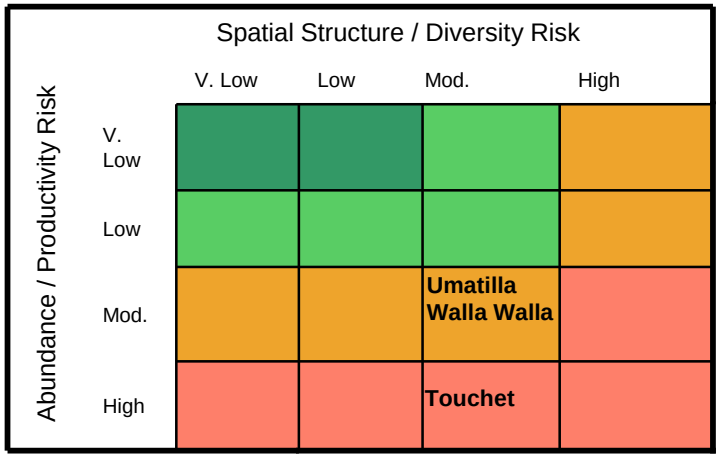
Cascades Eastern Slopes Tributaries Major Population Group.



Yakima River Major Population Group.



John Day River Major Population Group



Umatilla/Walla Walla Major Population Group

Figure 4-7. Viability Ratings for Middle Columbia Steelhead Populations by MPG (developed by NMFS based on ICTRT 2007a, http://www.nwfsc.noaa.gov/trt/col/trt_viability.cfm).

5. THE 'GAP' BETWEEN CURRENT AND DESIRED STATUS

The ICTRT assessed the difference between a listed species' or population's current abundance/productivity status and the viability criteria. This difference is called the "gap." The gap, as used in this plan, is a measure, although it is inevitably imprecise, of the improvement in survival needed to meet viability criteria. As such, it is also an indicator of the level of effort needed to achieve recovery. The following material is taken from the ICTRT's "Survival Gaps Report" (ICTRT 2007b) for the listed salmon and steelhead in the Interior Columbia Basin.

Although all four VSP parameters contribute to overall population and DPS viability, the gap is discussed quantitatively only in terms of abundance and productivity. Qualitative statements may be made about needed improvements to spatial structure and diversity, but the metrics—the methods of measurement—used to assess the risk levels of spatial structure and diversity are not easily summed up into a single statistic (See Section 4.3 of this Plan and ICTRT 2008).

A key part of the "gap" calculation is the productivity of the population. The ICTRT used a measure of productivity that directly relates to a population's potential to be self-sustaining, i.e., recruits per spawner, or the rate at which spawning adults in one generation are replaced by spawning adults in the next generation.

This measure of life-cycle productivity is affected by mortality and survival at all life stages, including juvenile mortality (such as the relative number or proportion of juveniles that die while migrating down river) and adult mortality (such as the relative proportion of adult fish harvested) (Figure 5-1).

The gap analysis itself does not identify or target a particular life stage for actions to achieve viability criteria. Gaps can be addressed by improvements to survival rates at any life stage (e.g., tributary residence, migration, estuary, early ocean, upstream migration), depending on the specific factors limiting the individual populations.

5.1 Gaps Using Abundance and Productivity Criteria

The ICTRT (2007c) estimated the minimal survival rate changes needed for Middle Columbia steelhead populations to meet the abundance and productivity viability criteria for a 5 percent risk of extinction in a 100-year time frame.

They used the following steps to estimate observed survival gaps:

1. Estimated current intrinsic productivity (defined by TRT as reproductive rate at low abundance) and natural spawner abundance (using the most recent 20 years of stock-recruit data).
2. Estimated current spawning level associated with achieving juvenile capacity.
3. Assigned each population to a risk category (very low, low, moderate, or high risk) based on its position relative to the viability curve for its size category.
4. Calculated gaps based on the minimum distance from the abundance/productivity point representing current status and the appropriate viability curve.

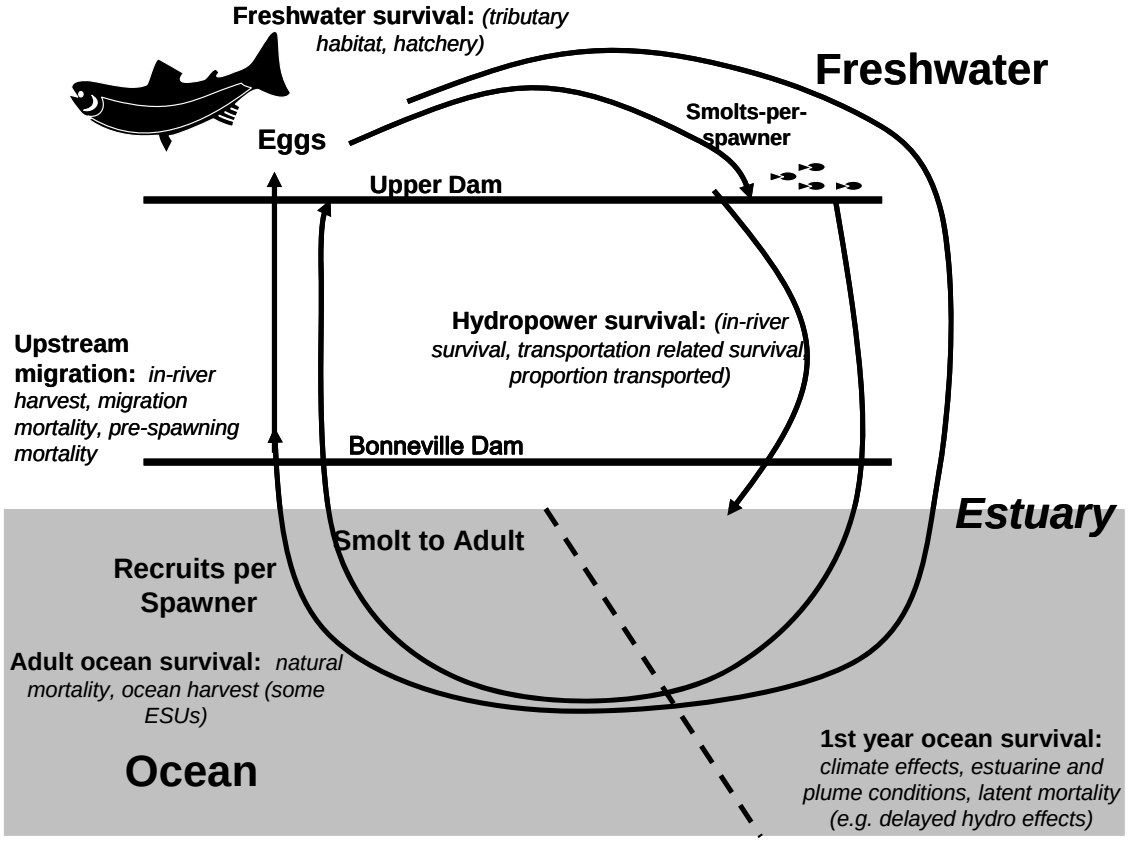


Figure 5-1. Survival and Mortality throughout Salmonid Life Cycle.

In addition, the ICTRT (2007b) estimated gaps under three different early-ocean survival scenarios; historical ocean conditions (ocean conditions that fish experienced over the past 60 years), pessimistic ocean conditions (ocean conditions experienced by the 1975-1997 brood years), and recent ocean conditions (ocean conditions experienced by fish during the 20-year assessment period). The ICTRT also estimated gaps assuming three different hydropower scenarios. However, only the base hydro condition, which assumed that survival rates from the most recent 20 years would continue into the future, is reported here. (See NMFS 2008a for details on survival through the FCRPS under proposed improvements.)

Changes in survivals of Middle Columbia steelhead needed to achieve the 5 percent risk criteria for abundance and productivity in a 100-year time period are presented in Table 5-1. The numbers in the table are expressed as a proportion of current survival. For example, in the table, an estimated gap of 0.09 for Umatilla steelhead requires increasing average life-cycle survival by 9 percent, or a 1.09 fold increase, to achieve 5 percent risk in a 100-year time period. A negative (minus) number means the population is viable.

The median survival gap (assuming recent ocean and base hydrosystem conditions and 5 percent risk) for the Cascades Eastern Slope MPG is 0.21, ranging from –0.34 (Deschutes Eastside) to 0.78 (Deschutes Westside). The Deschutes Eastside and Fifteen Mile populations

exceed the 5 percent abundance and productivity criteria under all ocean scenarios. In contrast, the Deschutes Westside fails to meet the criteria under all ocean scenarios. There was not enough information to estimate gaps for the Klickitat or Rock Creek populations.

The median survival gap for the John Day MPG is 0.09, ranging from –0.49 (North Fork) to 0.34 (South Fork). Two out of the five populations exceed the 5 percent abundance and productivity risk criteria under both the recent and historical ocean conditions. The North Fork population exceeds the 5 percent risk criteria under all ocean scenarios, while the South Fork population fails to meet the 5 percent criteria under all ocean scenarios.

There was sufficient information available to estimate gaps for only two of the three populations within the Umatilla/Walla Walla MPG. Assuming base hydrosystem and recent ocean conditions, the survival gaps for the Umatilla and Walla Walla populations are 0.09 and 0.34, respectively. The Umatilla population is projected to achieve the 5 percent risk criteria only under historical ocean conditions. The Walla Walla population fails to meet the 5 percent criteria under all ocean scenarios.

The median survival gap (assuming recent ocean and base hydrosystem conditions) for the Yakima MPG is 0.77, ranging from 0.22 (Satus—tributary only) to 1.15 (Upper Yakima). All populations in this MPG fail to meet the 5 percent criterion under all ocean scenarios.

5.2 Gaps using Spatial Structure and Diversity Criteria

As described in Section 4.3, the ICTRT analyzed a population's spatial structure and diversity in terms of two goals: maintaining natural rates and levels of spatially mediated processes, and maintaining natural patterns of variation. The team developed a scoring system, described in detail in Table 2-1 of Current Status Reviews, Vol. III (ICTRT 2008) to derive a composite spatial structure and diversity rating for each population. Using this method, the ICTRT rated only the Fifteenmile Creek and North Fork John Day populations at low risk of extinction with regard to spatial structure and diversity. The Upper Yakima River is at high SS/D risk, and the 15 other populations are rated at moderate risk.

It is important to include measures to address spatial structure and diversity risks in recovery planning. The Middle Columbia River steelhead DPS cannot reach viable status without closing these gaps as well as those identified in terms of abundance and productivity.

Summary

Using criteria for abundance and productivity, the ICTRT modeled a gaps analysis for each of the four MPGs in this DPS under three different ocean conditions and a base hydro condition (most recent 20-year survival rate). The results showed that none of the MPGs would be able to achieve a 5 percent or less risk of extinction over 100 years without recovery actions. It is important to consider that significant gaps in factors affecting spatial structure and diversity also contribute to the risk of extinction for these fish.

Table 5-1. Minimum changes in survival of Middle Columbia River steelhead needed to meet abundance and productivity criteria for 5 percent risk curves in a 100-year time period under base hydropower conditions and three different ocean scenarios. Gap estimates are expressed as a proportion of current survival (e.g., a gap of 0.50 requires increasing average life-cycle survival by 50 percent [multiplying by 1.5] over recent averages).

NOTE: A negative (minus) number means there is no gap – the population is viable. Data are from Table 6b in ICTRT (2007b); NA = not available.

Major Population Group	Population	Estimated abundance/productivity gaps (5% risk in a 100-year time period)		
		Recent ocean survival	Historical ocean survival	Pessimistic ocean survival
Cascades Eastern Slope	Deschutes W.	0.78	0.60	0.82
	Deschutes E.	No gap (-0.34)	No gap (-0.40)	No gap (-0.33)
	Klickitat	NA	NA	NA
	Fifteen Mile	No gap (-0.21)	No gap (-0.29)	No gap (-0.20)
	Rock Creek	NA	NA	NA
John Day	Lower Mainstem	0.11	0.00	0.14
	North Fork	No gap (-0.49)	No gap (-0.54)	No gap (-0.48)
	Upper Mainstem	0.00	No gap (-0.10)	0.02
	Middle Fork	0.09	No gap (-0.01)	0.12
	South Fork	0.34	0.21	0.37
Umatilla/Walla Walla	Umatilla	0.09	No gap (-0.01)	0.12
	Walla-Walla	0.34	0.21	0.37
	Touchet	NA	NA	NA
Yakima	Satus (tributary only)	0.22	0.10	0.25
	Toppenish	0.50	0.35	0.53
	Naches	1.03	0.83	1.08
	Upper Yakima	1.15	0.94	1.20

Note: These gaps do not constitute a legal determination of the status of Middle Columbia MPGs nor of the adequacy of any particular set of actions under the ESA. Rather, the gaps provide a sense of how much effort is needed for planning purposes.

6. LIMITING FACTORS AND THREATS

The reasons for a species' decline are generally described in terms of limiting factors and threats. NMFS defines limiting factors as the biological and physical conditions that limit a species' viability – e.g., high water temperature – and defines threats as those human activities or natural processes that cause the limiting factors. For example, removing the vegetation along the banks of a stream can cause higher water temperatures, because the stream is no longer shaded. Designing effective recovery strategies and actions requires understanding limiting factors and threats across the species' entire life cycle.

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are often legitimate human activities that may at times have unintended negative consequences on fish populations—and that can usually be managed in a manner that minimizes or eliminates the negative impacts.

For steelhead and other salmonids, survival to reproduce depends on a complex, interacting system of environmental conditions, with different conditions needed for each life stage. Optimal water temperature, for example, varies (within limits) for adult migration vs. egg incubation vs. juvenile rearing. In addition, the particular factors limiting production may vary across different sections of the tributary drainage used by a particular population. Data on a full range of potential limiting factors is rarely available at the reach level. As a result, the identification of limiting factors for salmonids often includes elements based on inference and expert opinion.

The list of limiting factors for the Middle Columbia steelhead DPS, as for the populations that make up the DPS, is based on a substantial body of research on salmonids, local field data and field observations, and the considered opinions of regional experts. These are implicitly hypothetical statements, made with the expectation that by taking action in the face of some degree of scientific uncertainty, monitoring the results, continuing to conduct research to resolve the uncertainties, and adapting our management actions in response, the state of our knowledge will improve and so will the survival of these fish, although not necessarily in a directly parallel process.

This plan describes limiting factors and threats for the Middle Columbia steelhead DPS as a whole at a general level, then describes the most salient specific conditions that affect individual populations and limit the viability of specific MPGs. More detail is available in the individual management unit plans and modules (Appendices A through G), as well as in the FCRPS BiOp (NMFS 2008a), particularly in the BiOp's Supplemental Comprehensive Analysis and Appendices, and in Appendix C of the Supplemental Comprehensive Analysis, Artificial Production for Pacific Salmon.

The discussion of out-of-subbasin limiting factors and threats that affect all the salmonid populations in the mainstem Columbia River corridor is excerpted from a "module" that NMFS prepared on the estuary and plume (NMFS 2007 and Appendix G of this Plan; available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm) and from the recently released 2008 FCRPS Biological Opinion (NMFS 2008a). NMFS also prepared a module to summarize FCRPS actions

contained in the Biological Opinion (Hydro Module, NMFS 2008c and Appendix F of this Plan), available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm. (The Estuary Module underwent public review; the Hydro Module, as a summary of the publicly reviewed BiOp actions, did not.) There is no hatchery module; hatchery programs are widespread throughout the Columbia Basin and their population-specific effects are described in the individual management unit plans.

6.1 Types of Limiting Factors

For recovery planning purposes, NMFS standardized descriptions of limiting factors into 12 categories or types. These are the categories of limiting factors used for the yearly Pacific Coast Salmon Recovery Fund (PCSRF) report to Congress in accordance with the PCSRF performance reporting framework (http://www.nwr.noaa.gov/Salmon-Recovery-Planning/PCSRF/upload/PCSRF-Perf-Framework.pdf). NMFS is working within the region to standardize definitions for monitoring and reporting. The descriptions of limiting factors in the management unit plans fit into these categories, although they may be lumped or split differently in the individual plan texts and also may be described slightly differently. However, Table 6-1 lists the 12 categories as "key" limiting factors, including the common characteristics used to describe them and the salmonid life stages they affect.

Table 6-1. Key limiting factors and common characteristics used to describe them.

Key Limiting Factors	Common Characteristics	Life Stages Affected
1. Degraded estuarine and nearshore marine habitat	Inadequate large woody debris; loss of estuary complexity; loss of off-channel habitats; loss of intertidal, salt marsh and other functional estuarine and marine vegetation.	egg-to-smolt survival, smolt migration, smolt-to-adult survival, adult migration
2. Degraded floodplain connectivity and function	Loss of off-channel habitat and floodplain connectivity, seasonal wetlands, wet meadows, side channels habitat; loss of connected and functional hyporheic zone.	egg-to-smolt survival, smolt migration, adult migration, pre-spawning
3. Degraded channel structure and complexity	Loss of pool frequency and quantity, large wood debris; channel straightening and confinement; simplified habitat; loss of spawning habitat structure, redd diversity; loss of sinuosity, insufficient instream complexity and roughness.	egg-to-smolt survival, smolt migration, adult migration, pre-spawning
4. Degraded riparian area and LWD recruitment	Degraded riparian condition; loss of vegetation, shade, overhead cover, terrestrial food sources; unstable or eroding stream banks.	egg-to-smolt survival, smolt migration, adult migration, pre-spawning
5. Altered hydrology	Higher peak flows, lower low flows; intermittent flow; increased stream energy; significant flow fluctuations on weekly, daily or hourly basis; dewatered channel.	egg-to-smolt survival, smolt migration, adult migration, pre-spawning
6. Degraded water quality	High water temperatures, high level of chemical contaminants, nutrients, oxygen, pathogens, pH, toxic mine waste.	egg-to-smolt survival, smolt migration, adult migration, pre-spawning
7. Altered sediment routing (degraded stream substrate)	Sedimentation; high levels of suspended sediment, turbidity, sediment load; increased fine sediments in spawning gravel; unnatural level of course-grained sediments; embedded substrate; contaminated sediment.	egg-to-parr survival
8. Impaired fish passage	Artificial barriers or obstructions, total or partially, obstructing habitat access (culverts, irrigation diversions, dams, seasonal push-up dams, unscreened diversions, and entrainment in irrigation diversions etc.).	smolt migration, adult migration, juvenile upstream migration due to thermal stress, water availability
9. Mainstem Columbia River hydro system effects	altered stream flows; impaired water quality, high water temperatures; impaired fish passage and survival; reduced mainstem spawning and rearing; increased predation and competition; degraded estuary and Columbia River plume habitat quality and quantity; degraded floodplains.	egg-to-smolt survival, smolt migration, adult migration
10. Hatchery-related adverse effects	Increased competition for food and space; increased predation; disease transfer; loss of genetic diversity.	egg-to-smolt survival, smolt migration, adult migration
11. Harvest-related adverse effects	Decreased adult abundance (number of spawners or adult recruits) and productivity; influenced diversity and spatial structure through selective removal based on size, age, distribution or run timing.	egg-to-smolt survival, adult survival
12. Predation/Competition/ Disease	Increase in predators; increased competition for food.	egg-to-smolt survival, smolt-to-adult survival, adult survival

6.2 Types of Threats

The threats contributing to the limiting factors and causes for a salmonid species' decline are often described in terms of the "four Hs" – habitat (usually relating to the effects of land use and tributary water use), hydropower, harvest, and hatcheries. Climate change also represents a potentially significant threat to salmon and steelhead.

6.3 Limiting Factors and Threats for the Middle Columbia Steelhead DPS

At the DPS level, based on information from the ICTRT and the four management unit plans, the major factors limiting the viability of Middle Columbia steelhead populations are *tributary habitat conditions (varying combinations of factors 2-7 listed in Table 6-1), impaired fish passage in the mainstem Columbia River and tributaries*, *hatchery-related effects, and predation/competition/disease*. Two factors, degradation of estuarine and nearshore marine habitat and harvest-related effects, pose some risk to steelhead viability for the entire DPS, but less than the other factors. Climate change could potentially affect habitat for all salmonids in the Columbia Basin.

Most of the management unit plans rate the importance of the limiting factors in their respective subbasins by population and also by smaller units such as stream reaches. There are some differences of opinion as to the general, relative importance of tributary habitat limiting factors vs. passage conditions in the mainstem Columbia. However, all of the plans list both as major limiting factors. Hatchery related effects on genetic diversity and productivity are considered a major limiting factor for populations in the Deschutes, John Day, and Umatilla basins, and possibly the Klickitat. The management unit plans provide detailed description and discussion of these factors as they apply to specific populations.

6.3.1 Tributary Habitat Conditions

For more than 10,000 years, habitat conditions favorable to salmonid survival were widespread in the Northwest. Over the last 150 years, human activities have significantly reduced the extent and quality of salmonid habitat. Tributary habitat degradation from past and/or present land use remains a key concern for all of the steelhead populations.

Historically, ecosystem conditions allowed steelhead populations in the spawning range of this DPS to grow and prosper. Extensive beaver activity created diverse instream habitats, with deep pools and strong connections to floodplains. Many stream channels contained abundant large wood from surrounding riparian forests, which included cottonwood, aspen, willow, and upstream conifers. Stream temperatures sufficient to support all steelhead life stages throughout the year were common. Upland and riparian conditions allowed for the storage and release of cool water during the dry, summer months and provided sufficient shade to keep water temperatures cool. Extensive and abundant riparian vegetation armored stream banks, providing protection against erosion and supporting an abundant food supply. Dynamic patterns of channel migration in floodplains continually created complex channel, side channel, and off-channel habitats.

Today, nearly all historical habitat lies in areas modified by human settlement and activities. Historical land use exerted a large and widespread impact on steelhead habitat quality and quantity across the DPS. Common historical practices included removal of wood from streams; removal of riparian vegetation; timber harvest, road construction, agricultural development, livestock grazing, urbanization, wetland draining, and gravel mining; alteration of channel structure through stream relocation, channel confinement and straightening; beaver removal; construction of dams for multiple purposes; and direct withdrawal of water for irrigation or human consumption.

While some streams and stream reaches retain highly functional habitat conditions, these various activities have degraded streams and stream reaches across the range of the Middle

Columbia steelhead DPS, leaving them with insufficient large wood in channels, insufficient instream complexity and roughness, and inadequate connectivity to associated wetlands and off-channel habitats. Many streams lack sinuosity and associated meanders and suffer from excessive streambank erosion and sedimentation, as well as altered flow regimes and higher summer water temperatures. In many areas, the contemporary watershed conditions created by past and current land use practices are so different from those under which native fish species evolved that they now pose a significant impediment to achieving recovery. The management unit plans contain detailed descriptions of tributary habitat threats and limiting factors.

6.3.2 Columbia River Mainstem Conditions

All populations of Middle Columbia steelhead use the mainstem Columbia River to migrate to and from the ocean, and all are affected by the mainstem Federal dams, as well as by other forms of development that alter the river environment. Mainstem Columbia River conditions include impaired fish passage, altered water temperature and thermal refuges, and changes in mainstem nearshore habitat.

6.3.2.1 Impaired Fish Passage

Development and operation of the mainstem Columbia River hydropower system significantly alters travel conditions in the mainstem Columbia River, resulting in direct mortality of both upstream migrating adults and downstream migrating steelhead kelts, and direct and indirect mortality for downstream migrating juveniles. The hydro system also changes the hydrograph, depleting historically available nutrients, changing water temperatures, and degrading rearing and food resources for both presmolts and smolts in the Columbia. Changes in the hydrograph leave steelhead more vulnerable to bird and fish predation in the Columbia River estuary and mainstem. In addition, broad deltas have been created at the mouths of tributaries where fine sediment has been deposited. These conditions have resulted in increased non-native piscivorous fish and avian predation on juveniles.

All these impacts increase somewhat for each population in direct relation to the number of dams that fish must pass during their migration to and from the Pacific Ocean. Middle Columbia steelhead populations pass one to four Columbia River dams. The Fifteenmile and Klickitat populations pass the Bonneville Dam; the Deschutes populations pass Bonneville and The Dalles dams; the John Day, Rock Creek, and Umatilla populations pass Bonneville, The Dalles, and John Day dams; and all four populations of the Yakima MPG as well as the Walla Walla and Touchet populations pass Bonneville, The Dalles, John Day, and McNary dams (Figure 6-1). While the hydropower system affects Middle Columbia steelhead less than the listed Interior Columbia salmonids that must pass up to nine mainstem dams, it still substantially affects most Middle Columbia populations.

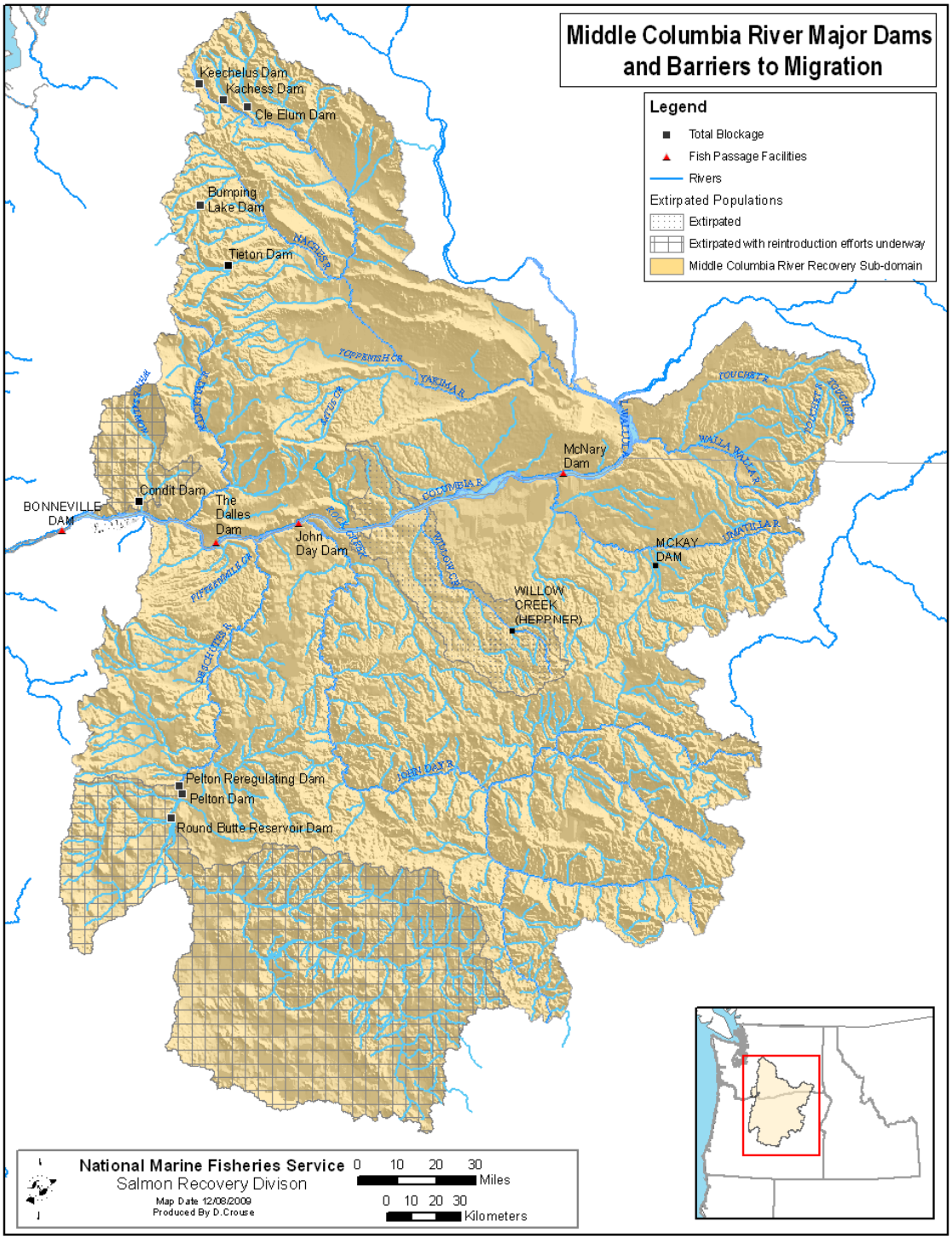


Figure 6-1. Major Dams and Barriers to Migration for Middle Columbia Steelhead.

Chapter 8 of the Oregon Steelhead Recovery Plan provides detailed information concerning the effects of the FCRPS on Middle Columbia steelhead; however, much must be inferred from studies of hatchery steelhead or Snake River steelhead because of a lack of specific survival data for the Middle Columbia steelhead DPS. Table 6-2 shows current estimates of survival of **juvenile** Middle Columbia steelhead migrating downstream through one to four dams. These estimates are based on COMPASS modeling of a 70-year water record (source: NMFS 2008a Supplemental Comprehensive Analysis—Hydro Modeling Appendix). They represent current conditions, reflecting improvements in the hydropower system made within the last decade. Juvenile survival is estimated at 90, 73, 54, and 48 percent, respectively, for passage through one to four dams. Juvenile mortality, conversely, is estimated at 10, 27, 46, and 52 percent.

Table 6-2. Middle Columbia River Steelhead DPS Juvenile Survival (migrating downstream) (Source: NMFS 2008a Supplemental Comprehensive Analysis—Hydro Modeling Appendix).

Population	Dams	% Survival
Fifteenmile	Bonneville	90
Klickitat		90
Deschutes West	The Dalles Bonneville	73
Deschutes East		73
Rock Creek	John Day The Dalles Bonneville	54
Lower Mainstem John Day		54
North Fork John Day		54
Upper Mainstem John Day		54
Middle Fork John Day		54
South Fork John Day		54
Umatilla		54
Walla Walla	McNary John Day The Dalles Bonneville	48
Touchet		48
Upper Yakima		48
Naches		48
Toppenish		48
Satus		48

Table 6-3 shows current estimates of **adult** survival for Middle Columbia steelhead migrating upstream through the dams.[32] These estimates are based on PIT-tagged steelhead from the Snake River as "surrogates." Adult steelhead survival is relatively high through the lower Columbia River dams and reservoirs as a result of dam operations and effective fish ladders.[33] There are known losses of adult fish approaching Bonneville Dam from marine mammal predation. For summer-run populations, this impact is likely minimal. For winter-run populations (Fifteenmile Creek, Klickitat, and possibly Rock Creek), the current impact may be as high as 22 percent (Source: NMFS 2008a Supplemental Comprehensive Analysis, Marine Mammal Predation Appendix).

Table 6-3. Middle Columbia River Steelhead DPS Adult Survival (migrating upstream) (Source: NMFS 2008a Supplemental Comprehensive Analysis, Adult Survival Estimates Appendix).

Population	Dams	% Survival
Fifteenmile	Bonneville	>98.5
Klickitat		>98.5
Deschutes West	Bonneville The Dalles	98.5
Deschutes East		98.5
Rock Creek	Bonneville The Dalles John Day	97
Lower Mainstem John Day		97
North Fork John Day		97
Upper Mainstem John Day		97
Middle Fork John Day		97
South Fork John Day		97
Umatilla		97
Walla Walla	Bonneville The Dalles John Day McNary	95
Touchet		95
Upper Yakima		95
Naches		95
Toppenish		95
Satus		95

[32] Adult steelhead detected at Bonneville Dam constitute the starting population for making survival rate estimates based on PIT tags. Consequently, no estimates of survival from the Bonneville tailrace to the detectors in the ladder are included in these estimates. However, based on the high inter-dam survival rates, this impact is likely small, except for winter-run populations, which may be substantially impacted by marine mammal predation in the Bonneville tailrace.

[33] It should be noted, however, that there are uncertainties in PIT-tag data for Upper Columbia steelhead compared to Snake River steelhead for the most recent two years, and it is not yet known how to interpret those data or how they apply to Middle Columbia steelhead adult survival estimates.

6.3.2.2 Water Temperature and Thermal Refuges

Optimal water temperatures for steelhead and salmon vary with life stage, but in general the optimal range is 11-15 °C (52-59 °F) and temperatures above 25 °C (77 °F) can be lethal. Alterations in water temperature affect the metabolism, growth rate, and disease resistance of salmonids, as well as the timing of adult migrations, fry emergence, and smoltification. As a result of the operation of the 14 FCRPS dams, in some areas and seasons the Columbia River is colder, and in others warmer, than before the dams (SCA Ch.5, NMFS 2008a). Since 1938, summer water temperatures at Bonneville Dam have increased 4 degrees on average (Lower Columbia Fish Recovery Board 2004). Among-year variability in temperature has been reduced by 63 percent since 1970 (Lower Columbia Fish Recovery Board 2004). Temperatures in the estuary exceed 20° C earlier in the year and more frequently than they did historically (National Research Council 2004). Coincident with and possibly due to climate change, average annual Columbia Basin air temperatures have increased by about 1 degree C over the past century and water temperatures in the mainstem Snake and Columbia rivers have been affected similarly (ISAB 2007). On the other hand, at some times of year temperatures in the lower Snake River may be lower than before, due to the release of colder water from the four lower Snake dams. This latter change has complex consequences; post-impoundment water temperatures may stay cooler longer into the spring and warmer later into the fall (called "thermal inertia"), and this in turn may affect adult migration, spawn timing, and juvenile emergence, rearing, and outmigration timing (SCA, NMFS 2008a).

When water temperatures are high, the fish may take refuge in cooler areas at the mouths of tributaries, and therefore delay migration and spawning or stray into the cooler rivers. It is possible that the Snake River hatchery steelhead that spawn in the Deschutes and John Day rivers are initially attracted to the thermal refuges at the mouths of these rivers.

6.3.2.3 Changes in Mainstem Columbia Nearshore Habitat

The mainstem nearshore environment has been changed by ports, population centers, railroad tracks, and highways, where riprap and docks have replaced riparian vegetation. Adverse effects include various contaminants, water temperature changes, loss of habitat complexity and associated rearing and refuge areas, loss of food resources, and stranding of juveniles. Relatively little information is available; more research is needed.

6.3.3 Impaired Fish Passage in Tributaries

Water management for agricultural irrigation alters seasonal flow patterns with serious consequences for steelhead rearing and both juvenile and adult migration in the Umatilla, Willow Creek, John Day, Deschutes, and especially the Yakima and Walla Walla basins. Dams, culverts, seasonal pushup dams, and unscreened diversions can directly prevent migration; seasonal areas of high water temperature, low flow, or dewatering can also function as barriers. In some tributary systems, local hydro-development blocks fish passage and results in flow modifications that affect water quality, habitat conditions, and predation rates. The Pelton-Round Butte Dam Complex on the Deschutes River blocks fish passage to upstream habitat on the Deschutes, Crooked, and Metolius rivers and smaller tributaries. Condit Dam blocks steelhead access to historical habitat on the White Salmon River. Five storage dams – Cle Elum, Kachess, Keechelus, Bumping Lake, and Tieton – block historical

habitat in the Yakima River basin. Bennington Dam, east of the City of Walla Walla on Mill Creek, a tributary of the Walla Walla River, was without fish passage until the 1980s. Subsequent improvements provide only partial passage, and Bennington Dam remains a significant passage obstruction that affects Walla Walla River steelhead. Numerous smaller barriers block or impair access to smaller tributaries throughout the basin.

In some tributary systems, local hydro-development also blocks fish passage (Pelton Dam on the Deschutes and Condit dam on the White Salmon) and results in flow modifications that affect water quality, habitat conditions, and predation rates (Pelton Dam on the Deschutes and Roza and Chandler Power Plants in the Yakima River system). Water management for agricultural irrigation alters seasonal flow patterns with serious consequences for steelhead rearing and both juvenile and adult migration in the Umatilla, Willow Creek, John Day, Deschutes, and especially the Yakima and Walla Walla basins.

6.3.4 Hatchery-Related Adverse Effects

Hatchery fish that stray into Middle Columbia tributaries and spawn naturally may represent a serious threat to steelhead recovery. More than 100 hatchery programs operate in the Columbia Basin above Bonneville Dam, mostly for the purpose of providing fish for harvest to mitigate losses caused by the FCRPS. Some hatchery programs may provide conservation benefits; however, hatchery programs also pose threats to natural-origin steelhead in some Middle Columbia watersheds. Hatchery-induced genetic change can reduce the fitness of both hatchery and natural-origin fish in the wild, and hatchery-induced ecological effects (competition for food and space) can reduce population productivity and abundance.

In particular, hatchery programs designed to return summer steelhead to upstream Columbia River tributaries result in substantial numbers of stray hatchery steelhead spawning naturally among several Middle Columbia populations. Concern exists regarding the continuing detrimental impact of these stray out-of-DPS hatchery fish in natural spawning areas on the genetic diversity and productivity of naturally produced Middle Columbia River steelhead populations. A large body of data indicates that steelhead of non-local origin can decrease the productivity and genetic diversity of natural populations (Fleming & Peterson 2001; McGinnity et al. 2003; Berejikian & Ford 2004, Myers et al. 2004). A recent study suggests that any interbreeding of hatchery-origin and naturally produced fish can pose risks to species fitness (Araki et al. 2007). The study suggested that use of natural-origin steelhead in a supplementation-type program is a possible strategy for increasing wild adults after one generation, but cautioned that long-term effects of supplementation are at present unknown and therefore a cause for concern in terms of potential impacts on fitness (Araki et al 2007).

The Oregon Steelhead Recovery Plan identifies hatchery practices and the effects of spawning stray hatchery fish as a key limiting factor and threat to the viability of the Deschutes River Eastside, Deschutes Westside, John Day, Umatilla, and Walla Walla populations. Out-of-DPS hatchery-origin spawners are estimated at 29 percent for Deschutes Eastside, 15.2 percent for Deschutes Westside, from 10 to 18 percent for Lower Mainstem John Day, and 5 percent for the Umatilla population (source: draft ICTRT Current Status Summary, Cooney 2008).

The Hatchery Scientific Review Group completed a review of hatchery programs in the Mid-Columbia steelhead DPS and released its recommendations in January 2009 (HSRG 2009).

The Oregon Steelhead Recovery Plan evaluates the hatchery strategies for each Oregon population to determine consistency with the HSRG recommendations.

Section 8.6 of the Oregon Steelhead Recovery Plan summarizes the specific hatchery programs and potential hatchery-related limiting factors for each of these populations. Within the Oregon portion of the Middle Columbia DPS, both the Round Butte hatchery program on the Deschutes River and the Umatilla hatchery program on the Umatilla River use endemic summer steelhead for broodstock. Out-of-basin hatchery smolts are released into the Walla Walla River as part of the Lower Snake River Compensation Plan. Washington Department of Fish and Wildlife operates the Lyons Ferry Hatchery, which is the only summer steelhead hatchery program in the Walla Walla basin. This hatchery program is being modified over time to reduce the impacts of non-endemic hatchery smolts released into the lower Walla Walla River with the goal of reducing genetic risks to the endemic steelhead population.

The John Day River steelhead populations are currently managed as wild populations and no hatchery production or supplementation occurs within the John Day River watershed. However, out-of-basin hatchery steelhead strays pose a primary threat to John Day steelhead populations. Hatchery steelhead coded-wire tag recoveries in the John Day subbasin from 1986 to 2003 identify 18 separate hatcheries as the sources of strays (Section 8.6.4 of the Oregon Steelhead Recovery Plan).

Releases of non-native Skamania stock hatchery fish in the Klickitat River may affect the Klickitat population. More data are needed to determine the effects of these hatchery fish on the productivity of the Klickitat population.

The Oregon Steelhead Recovery Plan notes that the number of out-of-basin hatchery-origin steelhead observed in the Deschutes River increased as mitigation programs developed in Columbia River watersheds (Section 8.6.3). A majority of these fish were produced in the Snake River Basin and at the Wallowa Hatchery. Both are funded under the Lower Snake River Compensation Plan.

More data are needed concerning the effect of all the combined hatchery releases on food supply and predation rates in the estuary (discussed further in Estuary Module). Pacific salmon at all abundance levels and at all life stages are subject to density dependent processes. Many factors influence these processes, including changes in habitat quality and quantity, prey base, the abundance and distribution of predators, natural fluctuations in environmental conditions (e.g., summer stream flows and ocean productivity), and interactions among species and between natural and hatchery fish that depend on the same natural environments. The question is how and to what extent hatchery-origin fish, in combination with these and other factors, affect density dependent processes and the growth and survival of natural-origin fish. There is increasing evidence of density dependent effects on salmon and steelhead growth and survival, but the underlying factor or factors remain poorly understood. Evaluating the factors that influence or drive density dependent effects under different freshwater (e.g., hydrosystem), estuarine, and ocean conditions is an important area of future research.

6.3.5 Predation/Competition/Disease

Anthropogenic changes in the Columbia River have altered the relationships between salmonids and other fish, bird, and pinniped species.

6.3.5.1 Pinnipeds

During the spring salmonid migration season, Steller sea lions, California sea lions, and harbor seals prey on salmon and steelhead in the Lower Columbia River as far upstream as the Bonneville Dam. California sea lions arrive in the greatest numbers (ranging from 31 to 111, 2002 to 2007, and averaging 82 individuals observed per year, compared to numbers in the single digits for Steller sea lions and harbor seals) (NMFS 2008d). They consume an estimated minimum of 1,000 to 4,000 (in-migrating adult) salmonids per year (ibid.). California sea lions and harbor seals are not ESA-listed, not considered depleted under the Marine Mammal Protection Act (MMPA), have increased in recent years and are considered to have stable populations that have reached carrying capacity for present ocean and breeding site conditions (Carretta et al. 2007, cited in NMFS 2008d). The Eastern United States stock of Steller sea lions (in this case, eastern refers to the eastern side of the Pacific Rim) is listed as threatened under the ESA and depleted under the MMPA. However, this population is stable or increasing throughout much of its range (ibid.).

The abundance of native pinnipeds has steadily increased since passage of the Marine Mammal Protection Act in 1972. The sea lions are estimated, based on visual observations and steelhead counts at Bonneville Dam, to consume 7.8 percent of winter-run steelhead (source: Marine Mammal Appendix, 2008 FCRPS BiOp). However, because of the difficulties of observing predation at the dam, comparisons of radio-telemetry data indicate that the consumption rate of spring Chinook salmon is likely 2.8 times higher (8.5 percent by radiotelemetry versus 3.0 by observation) than estimated using observational data alone. Applying this correction factor to winter-run steelhead would yield an estimate of 21.8 percent. Based on the relatively low numbers of steelhead passing Bonneville Dam during the winter months (0 to 140 individuals per day – Columbia River DART adult passage data for 2005 to 2008), even a small number of sea lions would be capable of consuming approximately 20 percent of the migrating winter steelhead (source: NMFS 2008a, Supplemental Comprehensive Analysis, Marine Mammal Appendix). This may represent a significant impact on the winter-run steelhead in the Middle Columbia DPS (primarily Fifteenmile Creek and Klickitat populations). Because of their migration timing, the summer-run steelhead populations that make up the bulk of the DPS are not likely substantially affected by pinniped predation.

6.3.5.2 Birds

Estuary habitat modifications have increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species. Juvenile steelhead, including Middle Columbia steelhead, are most vulnerable to predation by Caspian terns because they migrate at relatively shallow depths in deep water habitat channels that have relatively low turbidity and are close to island tern habitats (NMFS 2007; NMFS 2008a; Collis et al. 2007; Roby et al. 2008). They also tend to be larger than juveniles of other salmonid species. Caspian terns began nesting on East Sand Island in the Columbia estuary (RM 5) in 1984 and on Rice Island (RM 21) in 1986. The islands were formed by U.S. Army

Corps of Engineers' disposal of dredged material. On September 15, 1999, NMFS required the Corps to modify habitat on Rice Island to eliminate nesting habitat for Caspian terns. Since 2001, no Caspian terns have nested on Rice Island, resulting in reduced predation of juvenile salmonids from 11.7 million fish in 1999 to 6.5 million fish in 2002. Although total consumption of juvenile salmonids by terns was reduced considerably, a 2007 study found that predation rates on steelhead were 2-12 times higher than those for other salmonid species and run types (Roby et al. 2008). Based on smolt PIT tag recoveries on the East Sand Island Caspian tern colony, predation rates on steelhead smolts were particularly high during 2007, at about 12.5 percent for in-river migrant smolts and 7.7 percent for transported smolts.

Avian predation is also significant farther inland in the Middle Columbia region. Avian predator colonies on islands in the Columbia River include Caspian terns, double-crested cormorants, ring-billed and California gulls, and American white pelicans. The most significant populations of avian predators occur on Crescent Island (Caspian terns) and Foundation Island (cormorants), which are located in the Columbia near the mouth of the Snake River. In 2000 and 2001, bioenergetics modeling was used to estimate the smolt consumption rate of the Crescent Island tern colony at 465,000 and 679,000 smolts, respectively (Antolos et al. 2005). Approximately 25 percent of this consumption consisted of steelhead, including steelhead from the Yakima basin.

In 2005, an estimated 1 percent (22) of PIT tags from outmigrating Yakima River steelhead were subsequently recovered on the Crescent Island Caspian tern colony. In 2004, the figure was 2 percent (A. Evans, Real Time Research Inc., personal comm. 2006, as cited in the Yakima Recovery Plan). In 2005 only 0.1 percent (3 PIT tags) of PIT-tagged Yakima River steelhead were recovered on the Badger Island pelican colony (located just downstream from the mouth of the Yakima with more than 1057 adult birds present). PIT tag recoveries from the Foundation Island colony of double-crested cormorants, situated 8 km upstream of Crescent and Badger islands, indicated an overall steelhead predation rate about one-fifth as great as for the tern colony, though this is changing as tern numbers drop and cormorant numbers increase (Collis and Roby 2006). These rates do not account for ingested PIT tags deposited off the colonies, or for mortality (at least 50 percent for Yakima steelhead) of tagged fish between release sites and the Yakima River's mouth (Yakima Recovery Plan).

6.3.5.3 Piscivorous Fish

The dams on the Columbia River alter habitat conditions in several ways that are favorable to both native and nonnative fish species that prey on juvenile salmonids (NMFS 2008a). A recent report from the Independent Scientific Advisory Board, an appointed group of scientists advisory to the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and NMFS, summarizes these effects and concludes that predation by nonnative species is as significant as habitat loss and degradation in imperiling native freshwater species (ISAB 2008). The primary resident fish predators are northern pikeminnow (native), smallmouth bass (introduced), and walleye (introduced) (NMFS 2008a). Other predatory resident fish are channel catfish (introduced), Pacific lamprey (native), yellow perch (introduced), largemouth bass (introduced), and bull trout (native).

Impacts of the northern pikeminnow are concentrated in the lower Columbia River from The Dalles reservoir downstream, where the estimated predation loss is 8 percent of the approximately 200 million hatchery and wild juvenile salmonid migrants in the system (NMFS 2008a). The highest densities of smallmouth bass in the Columbia and Snake Rivers occur in the Lower Granite forebay, tailrace, and reservoir, followed by the John Day Reservoir (NMFS 2000a). Throughout the John Day Reservoir study area, smallmouth bass consumed far fewer juvenile salmonids than did northern pikeminnow (Zimmerman 1999). Walleye are also most abundant in the tailraces of the dams (NMFS 2008a). In the 1983-1986 John Day Reservoir study that forms the basis for the current predator management program, Rieman et al. (1991) found that walleye consumed 13 percent of the estimated annual 2.7 million juvenile salmonids consumed by predatory fish. Northern pikeminnow accounted for 78 percent and smallmouth bass took 9 percent (cited in NMFS 2008a).

6.3.5.4 Competition

Changes in habitat and high numbers of hatchery fish releases can also affect competitive relationships, resulting in increased competition between steelhead and other species for food and habitat (NMFS 2008a; ISAB 2008). Competition is often discussed in terms of density dependence. Density dependence refers to changes in the size of a population that are themselves a result of the size of the population, such as when a population declines because it has exceeded the amount of resources available to support it (NMFS 2007). Density dependent mortality can occur through several mechanisms, such as direct competition for limited food and habitat and changes in the foraging activity of predators. With salmon and steelhead, density dependent mortality can occur at any stage in the animal's life cycle and may be exacerbated by the introduction of large numbers of hatchery fish released over a relatively short period of time.

How much density dependent mortality is taking place in the estuary compared to the ocean is unclear. There is some evidence that density dependent mortality is occurring in the open ocean. For example, during years when salmon are especially numerous in the ocean, their growth rates are reduced (Peterman 1984). However, another study found no connection between ocean conditions and density dependent mortality, which appeared to be occurring among wild Snake River Chinook as hatchery steelhead were released (Levin and Williams 2002). The authors suggested that the apparent density dependent mortality could be better explained by interactions in the tributaries or estuary than by interactions in the ocean.

There is growing awareness among scientists studying the Columbia River estuary that mechanisms related to density dependence may limit salmon and steelhead while they are using estuary and plume habitats. Scientists studying Skagit River fall Chinook have documented density dependence-related mortality as a result of loss of habitat in the Skagit estuary and believe that such mortality can be attributed to a 75 percent loss of tidal delta estuarine habitat (Beamer et al. 2005). With similar habitat losses in the Columbia River estuary, it is possible that too many fish are competing for limited habitat and associated resources in the estuary at key times, and that the resulting stressors translate into reduced salmonid survival. The NOAA/NMFS Northwest Fisheries Science Center currently is investigating potential density dependent mortality in the estuary.

6.3.5.5 Disease

Steelhead can be infected by a variety of bacterial, viral, fungal, and microparasitic pathogens. Numerous diseases may result from pathogens that occur naturally in the wild or that may be transmitted to wild fish via infected hatchery fish. Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. However, studies have shown that naturally spawned fish tend to be less susceptible to pathogens than hatchery-reared fish (Buchanon et al., 1983; Sanders et al., 1992). Native salmon populations have co-evolved with specific communities of these organisms, but the widespread use of artificial propagation has introduced exotic organisms not historically present in a particular watershed. Habitat conditions such as low water flows and high temperatures can exacerbate susceptibility to infectious diseases. Fish weakened by disease are more sensitive to other environmental stresses, and may become more vulnerable to predation or less able to compete with other species. Aggressive hatchery reforms implemented in some areas have reduced the magnitude and distribution of hatchery fish releases, and consequently the interactions between hatchery- and natural-origin fish and the potential transmission of infectious diseases. Additionally, regulations controlling hatchery effluent discharges into streams have reduced the potential of pathogens being released into steelhead habitats. There is little or no information on specific impacts or trends in disease among Middle Columbia steelhead.

6.3.6 Degradation of Estuarine and Nearshore Marine Habitat

The estuary serves an important role beyond simply providing a corridor that Interior Columbia populations use to migrate between freshwater and the ocean. The estuary is part of the continuum of ecosystems that salmon and steelhead use to complete their life cycles. A variety of anthropogenic factors and natural changes to the estuary have affected all VSP parameters, particularly alterations in flows, loss of emergent marsh, tidal swamp, and forested wetlands, shifts in organic matter important to estuarine food webs, and changes in the plume. Changes in the plume may have a greater effect than changes in shallow-water habitat on salmonids with yearling life history strategies such as the Middle Columbia steelhead DPS. Exposure to waterborne and sediment-associated chemical contaminants such as pesticides and dissolved metals can also affect productivity of salmon and steelhead. Finally, predation in the estuary is a major source of mortality on both adults and juveniles of all listed populations. These issues are discussed in greater detail in the Estuary Module (NMFS 2007).

6.3.7 Harvest

Fisheries that harvest salmon and steelhead of the Columbia River are established within the guidelines and constraints of the Pacific Salmon Treaty, the Pacific Fishery Management Council, the states of Oregon and Washington, the ESA administered by NMFS, and management agreements negotiated between the parties to *U.S. v. Oregon*. Fisheries management through these various organizations has resulted in the decline of total exploitation rates for Columbia River salmon and steelhead, especially since the 1970s. Because of these changes, the ICTRT currently considers harvest a secondary limiting factor for Oregon Middle Columbia steelhead populations.

6.3.7.1 Ocean Fisheries

It is assumed that steelhead are rarely caught in ocean fisheries because they tend to be distributed offshore of major fishing areas and are therefore not readily available. According to Rich (1942), Columbia River steelhead were historically taken along with Chinook and coho in ocean fisheries off the mouth of the Columbia River, but accounted for less than 0.1 percent of the catch and numbered only in the few hundreds of fish. Current ocean fisheries generally target Chinook and coho salmon, and interception of steelhead is believed to be rare. If caught, steelhead must be released. Creel surveys on recreational ocean fisheries recorded less than 100 steelhead (of any DPS) caught each year from 2003 to 2005. Of these, less than 10 were estimated to be released wild fish mortalities. Ocean fishing mortality on Middle Columbia River steelhead is assumed to be zero.

6.3.7.2 Mainstem Columbia Fisheries

Harvest rates on the Middle Columbia steelhead DPS in the past, e.g. prior to 1975, were estimated at 65 percent in fisheries occurring in the Columbia River. Current rates are much lower. There has been no direct freshwater non-tribal harvest on wild steelhead from the Middle Columbia DPS since 1992, when the last wild fish catch and release regulations on these populations became effective. Therefore, all current non-tribal harvest impacts on Middle Columbia DPS steelhead are due to incidental bycatch in commercial or recreational fisheries that target hatchery steelhead or other species. Monitoring these impacts is complex. Information assessing catch and release mortality of adult steelhead is limited. However, available information suggests that hook-and-release mortality is low. Hooton (1987) found catch and release mortality of adults in winter steelhead fisheries to be, on average, less than 5 percent when barbed and barbless hooks, bait and artificial lures were used; Hooton (1987) concluded that catch and release of adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream as well as steelhead not hooked and played to exhaustion. Similarly, Nelson et al. (2005) observed that the catch and release mortality for radio-tagged wild winter steelhead was 2.5 percent and that tagged steelhead survived to spawning even after being caught and released up to three times. Mongillo (1984) and Rawding (2000) reported a strong correlation between water temperature and catch and release mortality, with water temperatures below 50F (10C) providing optimal survival, while temperatures above 60F (15.5C) increase the mortality rate. Recreational fisheries are monitored by creel surveys. (Fisheries technicians interview anglers about their catch, gear, and wild steelhead releases.)

Tribal treaty fisheries are managed through the *U.S. v. Oregon* process. *U.S. v. Oregon* is the result of the Federal government intervening in Federal court to protect tribal treaty reserved fishing rights in the Columbia Basin. A 10-year agreement (through 2017) is now in place to govern mainstem Columbia River fishing (NMFS 2008a). Harvest impact is limited to ESA incidental mortality limits set by NMFS. Within these ESA limits, the states and tribes negotiate how harvest will be allocated, with the objective being to balance the catch between them. All of the fisheries are abundance-based, with higher harvest rates allowed as ESA-listed adult returns increase.

There is a standing technical committee, the TAC (Technical Advisory Committee), to help monitor the fisheries. The TAC, using models, develops pre-season estimates of adult returns, updates these estimates in-season based on dam counts, and monitors the fisheries in season. The fisheries (both state and tribal) are adjusted based on the in-season run forecasts to stay within the ESA impact limits. Most of the time the fisheries take less than the ESA impact limit. The states provide real time updates of the fisheries, accessible to the public via the Internet, during periods of fishing. There is usually a post-season review of the fishery. In summary, NMFS sets ESA limits; the states and tribes negotiate how the harvest will be allocated, with the objective being to balance the catch between them.

Three stocks of summer steelhead are used for management of treaty and non-treaty mainstem fisheries: lower river Skamania stock, upriver A-run stock, and upriver B-run stock. All Middle Columbia steelhead populations are designated A-run, with two populations being winter-run. In NOAA Biological Opinion for the 2008-2017 *U.S. v. Oregon* Fisheries Agreement (NMFS 2008b), the wild Middle Columbia steelhead DPS in the non-treaty winter, spring, and summer mainstem fisheries are subject to a 2 percent harvest rate limit (NMFS 2008b). Non-treaty fall fisheries are also limited to a 2 percent harvest rate for A-run summer steelhead. The total annual harvest rate limit for A-run steelhead in non-treaty fisheries is 4 percent and 2 percent for the summer-run and winter-run of the Middle Columbia steelhead DPS respectively. The expected actual harvest impacts from non-treaty fisheries are less than the limits proposed in the *U.S. v. Oregon* Fisheries Agreement. The yearly incidental catch of A-run steelhead in non-treaty fisheries has averaged 1.6 percent since 1999, and is not expected to change over the course of the Agreement (NMFS 2008b).

Tribal fishers in Zone 6 of the Columbia mainstem (between Bonneville Dam and McNary Dam) continue to retain wild steelhead for commercial sale or for personal use. The *U.S. v. Oregon* Fisheries Agreement does not establish specific harvest rate limits for treaty Indian fisheries on steelhead during the spring or summer seasons, which extend through July 31. Reported steelhead catch in Zone 6 winter and spring fisheries for 2003 to 2005 ranged from 0.7 percent to 7.9 percent of the winter steelhead run over Bonneville Dam. In 2004, reported and estimated non-reported steelhead catch together amounted to 4.8 percent of the run at Bonneville, with an unknown error around these numbers (Oregon Steelhead Recovery Plan, p. 8-98).

Impacts on Middle Columbia steelhead from Treaty Indian fall fisheries are limited by harvest rate limits for B-run steelhead and Upper Columbia River bright fall Chinook (NMFS 2008b). The harvest rate on Middle Columbia summer-run steelhead in spring, summer, and fall Zone 6 Treaty Indian fisheries combined averaged 11.7 percent since 1985 and 6.64 percent since 1998 (Table 8.8.5.5-1; NMFS 2008b). The impacts resulting from the Treaty Indian fisheries are expected to be similar to the 1998-2006 average of 6.64 percent. The harvest rate is less for populations that pass fewer dams in Zone 6 and are therefore subject to fewer non-Indian and treaty Indian fisheries (e.g. Klickitat steelhead pass only one dam and would experience a harvest rate less than 6.64 percent). Mainstem harvest rates are estimated to be less than 8.54 percent for natural Middle Columbia steelhead (NMFS 2008b).

Oregon and Washington have proposed regulations for tributary recreational fisheries in Fisheries Management and Evaluation Plans (FMEPs) submitted to NMFS for approval under the limit 4 of the 4(d) rule. All recreational steelhead fisheries are restricted to adipose fin-clipped hatchery steelhead only. WDFW estimates that in 2002 fisheries, the impacts on Middle Columbia steelhead from all fisheries were 7.5 percent for the Treaty Columbia River mainstem and tributary fisheries, less than 4.0 percent for the non-treaty Columbia River mainstem fisheries, and 0.3 percent in Washington tributaries, for a total impact of less than 12 percent (WDFW 2008).

ODFW performed a number of Population Viability Assessment model runs for 27 steelhead populations to assess the impact of fisheries mortality on the status and recovery of steelhead in Oregon (Chilcote 2001). The model looked at a range of fisheries mortalities from 0 percent to 75 percent. The results were stated in terms of the probability of the population becoming extinct in 50 years at each fisheries mortality rate. For most populations the modeling suggested that the probability of extinction was essentially zero as long as fisheries mortality rates remained less than 30 percent. As mortality rates became greater than 40 percent, the probability of extinction increased dramatically. Furthermore, once the probability of extinction increased beyond 0.05, the transition to an extinction probability of 1.00 was very rapid. In other words, once mortality rates increase sufficiently to cause the probability of extinction to exceed 0.05, any additional mortality would cause a rapid increase in the likelihood of extinction. Because the transition from low to high risk happens so rapidly, there is little room for error (in the model or the measurements of mortality rates). To address this concern, fisheries co-managers will manage steelhead fisheries not to exceed a maximum fisheries mortality limit to 20 percent. This conservative approach was used to provide a buffer for errors, even though the model results suggested that management under a 40 percent limit was unlikely to cause extinction.

6.3.8 Climate Change

The Independent Scientific Advisory Board (ISAB) for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and NMFS reviewed the potential effects of climate change on salmonids in the Columbia River basin (ISAB 2007). As described in that report, changes in climate in the Pacific Northwest have affected both habitats and species, and those effects are expected to continue in the future. Climate records show that the Pacific Northwest has warmed about 1.0 °C since 1900, or about 50 percent more than the global average warming over the same period. The warming rate for the Pacific Northwest over the next century is projected to be in the range of 0.1 to 0.6 °C per decade. While projected precipitation changes are predicted to be indistinguishable from natural variability until late in the 21st century, most models project long-term increases in winter precipitation and decreases in summer precipitation.

The ISAB report shows that changes in climate may adversely affect steelhead in freshwater habitats across the DPS by exacerbating existing problems with water quantity (lower summer stream flows) and water quality (higher summer water temperatures). Consistently identified types of impacts on snow pack, stream flow, and water quality in the Columbia Basin are the following (ISAB 2007):

- Warmer temperatures will result in more precipitation falling as rain rather than snow.
- Snow pack will diminish, and the timing of stream flows will be altered.
- Peak river flows will likely increase.
- Water temperatures will continue to rise.

These changes in air temperatures and river flows will cause changes to the physical and chemical habitat in the mainstem river and tributary streams, which will elicit a response in the biological communities living in those habitats. These changes will affect all salmonid life stages, and range from changes in run timing or movement because of warmer water temperatures, to changes in species composition with a shift toward species more tolerant of warmer water temperatures. ISAB (2007) predicts changes in interspecies interactions and increased physiological stressors on fish. These changes may affect steelhead more than other salmonids because of their long rearing period in freshwater. More detailed information on specific effects that climate change may have on Mid-Columbia steelhead at all their life stages is available in Section 8.8 of the Oregon Steelhead Recovery Plan (ODFW 2009).

Changing conditions could also affect salmonid health and survival in the ocean through a variety of mechanisms, including increased ocean temperatures, increased stratification of some waters, changes in the upwelling season, shifts in the distribution of salmonids, long-term variability in winds and ocean temperatures, increased acidity, and increased atmospheric and oceanic variability (NMFS 2007, 2008a; ISAB 2007).

All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat can be expected to cause a reduction in the number of naturally produced adult steelhead returning to these populations across the DPS. This possibility further reinforces the importance of achieving survival improvements throughout the entire steelhead life cycle. Recent research also indicates that neighboring populations with differences in habitat may show different responses to climate changes (Crozier and Zabel 2006; Crozier et al. 2008). This research reinforces the importance of maintaining habitat diversity. Ongoing efforts to develop models of future climate effects should be considered in adaptive management.

6.4 MPG Limiting Factors

The MPG-level summaries of limiting factors are based on population-level summaries compiled from the relevant management unit plans.

6.4.1 Cascades Eastern Slope Tributaries MPG

The following are major limiting factors for the Cascades Eastern Slope Tributaries MPG:

Tributary habitat. Degraded tributary habitat is a limiting factor to a greater or lesser degree throughout the area, including degraded riparian areas, reduced LWD recruitment, altered sediment routing, low or altered stream flows, degraded water quality (especially high water temperatures), impaired floodplain connectivity/function, altered channel structure/complexity, and impaired fish passage.

Mainstem passage. Mainstem Columbia River hydro system effects are least for the Fifteenmile Creek and Klickitat River populations, which pass only one mainstem dam. The Deschutes River populations pass two mainstem dams, and the Rock Creek population passes three.

Hatchery related effects. Influence from hatchery fish could be a significant factor for this MPG because of out-of-subbasin straying onto natural spawning grounds in the Deschutes River and also because of potential effects of hatchery releases on naturally produced steelhead in the Klickitat River. The Oregon Mid-C Expert Panel considered out-of-subbasin (and out-of-DPS) hatchery strays a primary threat to genetic traits and productivity of naturally produced Deschutes river steelhead populations. Out-of-DPS hatchery strays comprised an average of 29 percent of the Eastside population and 15.2 percent of the Westside population over the past three generations. This high fraction resulted in moderate risk ratings for spawner composition for both populations.

Blocked migration to historically accessible habitat. Historically, summer steelhead had free access to most of the Deschutes watershed, including the Crooked River, Metolius River, Deschutes River upstream to Big Falls, and Whychus Creek. Summer steelhead were historically present throughout much of the Crooked River basin, with the exception of the North Fork Crooked River above Upper and Lower Falls. Steelhead were still present in the Crooked River until the mid to late 1950s, and were occasionally caught by anglers. Now the Pelton-Round Butte Hydroelectric Project (Project), constructed at river mile (RM) 100 on the mainstem Deschutes River, creates the primary barrier to anadromous fish attempting to reach spawning and rearing areas in the upper basin. The project was completed in 1964 with upstream and downstream fish passage facilities. However, by 1966 it appeared that downstream passage through Lake Billy Chinook, the reservoir behind Round Butte Dam, could not be maintained because of poor guidance of out-migrating smolts. The last fish were passed in 1968. Currently, plans are underway to reinitiate fish passage facilities at the Pelton-Round Butte complex and reintroduce steelhead to the upper basin (details in Section 9.4.2 of the Oregon Steelhead Recovery Plan). The second large barrier to upstream fish migration into the Crooked River is Opal Springs Dam at RM 7. Agencies and stakeholders are working together to address fish passage issues (see Section 8.2.4 in the Oregon Steelhead Recovery Plan).

Historically, summer and winter steelhead spawned in the White Salmon subbasin. Condit Dam, constructed in 1913 on the mainstem White Salmon River, blocks all anadromous fish migration to historical habitats in the upper subbasin. Condit Dam is scheduled to be removed in 2010.

Predation/competition/disease. Predation, competition, and disease issues in mainstem and estuary affect all of the Middle Columbia steelhead populations (see Section 6.3.5). In addition, the Oregon Steelhead Recovery Plan hypothesizes that the abundance of the Deschutes River Westside population may be limited by competition with a large resident population of rainbow trout.

6.4.2 John Day River MPG

The following are major limiting factors for the John Day River MPG:

Mainstem passage. These populations must pass three dams; thus, limiting factors include direct mortality of pre-smolts and smolts at John Day, The Dalles, and Bonneville dams; delayed upstream migration of returning adults; false attraction of returning adults over McNary Dam; and cumulative impact of hydropower system on mainstem and estuary habitat (see Hydro Module, NMFS 2008c).

Hatchery related effects. Out-of-DPS hatchery fish straying into natural spawning areas (10 to 18 percent in the Lower Mainstem John Day) pose risks to genetic traits and productivity of naturally produced steelhead. Concern over competition for resources with wild fish and potential hybridization with natural-origin fish resulted in termination of all hatchery stocking of *O. mykiss* in the John Day River basin in 1997. Most hatchery stray recoveries occur in the Lower Mainstem John Day below the North Fork; however, strays have been observed in all populations.

Tributary habitat. For all five John Day populations, degraded floodplain and degraded channel structure (key habitat quantity and habitat diversity), altered sediment routing, water quality (temperature), and altered hydrology are limiting factors. For the Lower and Upper Mainstem and South Fork populations, passage obstructions in some of the smaller tributaries are also significant.

Predation/competition/disease. Predation, competition, and disease issues in mainstem and estuary affect all of the Middle Columbia steelhead populations.

6.4.3 Umatilla/Walla Walla MPG

The following are the major limiting factors for the Umatilla/Walla Walla MPG:

Mainstem passage. The Walla Walla and Touchet populations must pass four major dams; the Umatilla population must pass three.

Tributary habitat. For all three populations, water quality (temperature), sediment, blocked and impaired fish passage, degraded floodplain and channel structure (key habitat quantity and habitat diversity) and hydrologic alterations are limiting factors.

On the lower Umatilla River, six major irrigation diversions withdraw enough water to dewater the river in mid-summer. McKay Dam blocks fish passage to 108 miles of historically accessible habitat. Bennington Dam, east of the City of Walla Walla on Mill Creek, a tributary of the Walla Walla River, is a significant passage obstruction. The Mill Creek flood control channel through Walla Walla is also a significant passage obstruction.

Hatchery related effects. The hatchery program on the Umatilla River uses endemic (native) stock and is not currently considered a threat to wild steelhead; however, out-of-DPS strays pose a risk to spawner composition. The hatchery program on the Walla Walla and Touchet rivers uses non-endemic stock, but an endemic stock program is under development. Non-endemic-origin hatchery fish from mitigation releases into the lower Walla Walla River have been straying into upper river natural production areas at relatively low levels. Recent smolt releases in the program have been reduced. Future levels of straying are uncertain, and

additional actions may be necessary. Currently, data are insufficient to determine whether hatchery effects are a problem for wild steelhead in the Touchet River.

Predation/competition/disease. Predation, competition, and disease issues in mainstem and estuary affect all of the Middle Columbia steelhead populations.

6.4.4 Yakima River MPG

The following are the primary limiting factors for the Yakima MPG:

Mainstem passage. As the farthest upstream populations in the DPS, the Yakima populations must pass four dams and undergo higher exposure to altered habitat and avian and piscine predators in the mainstem Columbia.

Tributary habitat. Fish habitat in the Yakima subbasin is substantially influenced by the development of irrigation systems. Limiting factors include altered hydrology (low summer flow, scouring peak flows due to degraded watershed conditions, high summer delivery flows in mainstem Yakima and Naches rivers, reduced winter and spring flows due to irrigation storage, delivery, and withdrawals); degraded riparian area and LWD recruitment; impaired fish passage (dams, culverts, seasonal push-up dams, entrainment in unscreened diversions); altered sediment routing; degraded water quality; loss of historical habitat because of blocked or impaired fish passage; degraded floodplain connectivity and function (loss of off-channel habitat, side channels and connected hyporheic zone); degraded channel structure and complexity; reduced outmigrant survival in the mainstem Yakima.

Hatchery related effects. The Yakima populations have the lowest rates of hatchery strays in the DPS, and hatchery effects are not considered a significant limiting factor.

Predation/competition/disease. Of the Middle Columbia steelhead populations, the Yakima basin populations have the longest migration through the mainstem Columbia River. They may therefore be more vulnerable to some factors such as avian and piscivorous fish predation. For example, Yakima steelhead, but not the others, are consumed by Caspian tern and double-crested cormorants nesting on islands at the mouth of the Snake River.

7. RECOVERY STRATEGY

The preceding chapters summarize recovery goals, biological criteria and threats criteria, current status assessment, the gap between current status and desired viability, and the major limiting factors and threats identified for the Middle Columbia steelhead DPS. This information helps us understand what recovery would look like, but how will we get there?

NMFS' overall goal for DPS viability, as formulated by the ICTRT and described in Chapter 3 of this plan, is to have all four extant MPGs at viable (low risk) status, with representation of all the major life history strategies present historically, and with the abundance, productivity, spatial structure and diversity attributes required for long-term persistence.

The ICTRT's current status assessment for the Middle Columbia steelhead DPS and the gaps analysis show that for this DPS, the outlook is optimistic. One population, North Fork John Day, is currently at very low risk or "highly viable." Two populations are currently viable (Deschutes Eastside, Fifteenmile); eleven are at moderate risk, with good prospects for improving. However, the three large populations at high risk (Deschutes Westside, Naches, and Upper Yakima), are important to DPS viability; as a minimum, Deschutes Westside and one of the two large Yakima populations should also reach viable status, with the other large Yakima population at least reaching "maintained" status. These present significant, though not insuperable, challenges.

If, as we believe, the decline of the Middle Columbia River steelhead DPS is caused by widespread habitat degradation, impaired mainstem and tributary passage, hatchery effects, and predation/ competition/ disease, then actions taken to improve, change, mitigate, reduce those factors will result in reduced risks and increased survival. Because of the steelhead's complex life cycle and the many changes that have taken place in its environment, the factors limiting its survival must be addressed in concert, and in an integrated way. The work needs to occur at a regional level, in terms of commitment to actions and funding, and at the local level, population by population and site by site. Significant investments of research, planning, regional coordination, actions, and political will are already underway. The intent for the DPS plan is to build upon, help to coordinate, and add to the ongoing efforts.

NMFS' 2006 listing decision called upon Federal, state, and tribal entities to do their best to manage land, hydropower, hatchery, and harvest activities in a manner that would support steelhead recovery. This plan reaffirms those recommendations and adds to them the contributions of updated science, basinwide programs, and consensus building among stakeholders. While Federal, state, and tribal entities can make major contributions to the recovery of Middle Columbia steelhead, the actions of individuals on their land, as well as city and county codes and ordinances promoting conservation, are also essential.

The recovery strategy for the Middle Columbia steelhead DPS addresses both the basin-wide issues that affect all populations, such as conditions in the migratory corridor, and the subbasin and site-specific issues that are the focus of the management unit plans. The DPS Plan describes the overall strategy, summarizes the MPG-level strategies, and refers to Appendices A-G for more site-specific, population level actions.

7.1 DPS Level Recovery Strategy

The DPS-level recovery strategy for the Middle Columbia steelhead is made up of the following elements:

- Affirm and address the 2006 listing decision recommendations regarding the limiting factors for the DPS and populations.
- Protect and restore tributary habitat and Columbia River mainstem habitat, through strategies and actions at both the Basin/programmatic level and at the local level as detailed in the management unit plans.
- Address impaired fish passage through strategies and actions in the mainstem Columbia River, as detailed in the 2008 FCRPS Biological Opinion (as summarized in the Hydro Module) and in the tributaries as detailed in the management unit plans.
- Implement hatchery reforms at the population and site-specific level through Hatchery and Genetic Management Plans (HGMPs) as required by the 2008 FCRPS Biological Opinion and as described in Appendix C of the Supplemental Comprehensive Analysis (NMFS 2008a).
- Address ecosystem imbalances in predation, competition, and disease through the strategies and actions in the management unit plans, estuary module and FCRPS Biop.
- Maintain current low harvest levels, through fishery management planning for mainstem fisheries through the *U.S. v. Oregon* 10-year agreement, updated Fisheries Management Evaluation Plans and Tribal Resource Management Plans for tributary fisheries, and Pacific Salmon Treaty and Pacific Fishery Management Council processes.
- Protect and restore the estuary and Columbia River plume as detailed in the Columbia River Estuary module.
- Respond to climate change threats with a strategy based on the principle of preserving biodiversity.
- Implement the Plan through effective coordination and governance.
- Research critical uncertainties, monitor and evaluate implementation and effectiveness and adjust course as appropriate through adaptive management.

NMFS believes that if this strategy is implemented and the biological response is as expected, the Middle Columbia steelhead DPS is likely to achieve viable status within 25 to 50 years.

The following sections describe the recovery strategy elements in more detail. The chapter concludes with summaries of the MPG-level strategies.

7.1.1 NMFS 2006 Listing Decision Recommendations

In both NMFS' 2004 proposed listing decision (69 FR 33165) and its 2006 final listing decision (71 FR 834), NMFS listed 11 "conservation measures and commitments that if implemented might substantially address key limiting factors, ensure viability over the long

term, and likely bring Middle Columbia River steelhead to the point where the protections of the ESA are no longer necessary," as follows:

(1) Continued funding by the Bonneville Power Administration (BPA) of DPS-wide riparian zone and instream habitat restoration efforts, consistent with its Fish and Wildlife Program's portion of the subbasin and recovery plans being developed;

(2) Adherence by the BLM to best management practices for grazing, mining, and recreational activities DPS-wide;

(3) Adherence by the U.S. Forest Service to best management practices for grazing, forestry, and mining activities DPS-wide;

(4) Continued conservative fisheries management by the Washington Department of Fish and Wildlife within the range of this DPS, and development and implementation of a long-term approach that balances natural and hatchery production across the DPS;

(5) Continued conservative fisheries management by the Oregon Department of Fish and Wildlife (particularly in the John Day River subbasin), development and implementation of management approaches to reduce the straying of out-of-basin stocks into Deschutes and John Day spawning areas, and development and implementation of a long-term approach that balances natural and hatchery production across the DPS;

(6) Improved passage and flow management by the U.S. Bureau of Reclamation below all its facilities in the Yakima River and the Umatilla River subbasins, provision of fish passage into significant tributaries, and provision of passage over at least two of its storage dams in the Yakima Basin[34];

(7) Provision for passage in the Deschutes River subbasin above the Pelton/Round Butte complex by the Federal Energy Regulatory Commission (FERC); restoration of downstream water temperature regime to historical levels, and provision for upstream/downstream habitat enhancement and restoration;

(8) Improvement of fish passage, screening, and flow management in the Walla Walla River subbasin by the U.S. Army Corps of Engineers, and alteration of the flood operating rule for Mill Creek, or alternatively screening the diversion into Bennington Lake;

(9) Continued conservative hatchery and harvest management by the Yakama Nation and adherence to best land management practices;

(10) Continued conservative hatchery and harvest management by the Confederated Tribes of the Umatilla Reservation; and

[34] The conservation measures in NOAA's 2006 listing decision specifically identify the need for passage at two or more of the storage dams in the Yakima Basin. The Yakima Steelhead Recovery Plan strongly recommends the provision of passage at the storage dams, but notes that the geographic distribution criteria detailed in the plan provide for combinations of spawning areas that would meet delisting and short-term recovery thresholds without provision of access above the storage dams (See Appendix E, Section 4.3.7).

(11) Continued adherence to best land management practices by the Confederated Tribes of the Warm Springs Reservation in the Deschutes River subbasin.

These recommendations call upon Federal, state, and tribal entities to do their best to manage land, hydropower, hatchery and harvest activities in a manner that would support steelhead recovery. NMFS reaffirms these recommendations. Also, with two thirds of its range in private ownership, recovery for Middle Columbia River steelhead will depend on voluntary participation of landowners.

7.1.2 Tributary and Columbia Mainstem Habitat

Actions to protect and improve habitat in the tributaries and Columbia mainstem are essential to achieving recovery objectives for the Middle Columbia steelhead DPS. Unlike some other salmonid species, steelhead, which are "stream-type" salmonids, use mainstem tributary, upper tributary, and side channel habitats for spawning, juvenile rearing, and overwintering. Steelhead populations are particularly susceptible to the effects of degraded freshwater habitat because most steelhead spend one or more years in freshwater before migrating. While improving survival in the mainstem Columbia River and estuary is also an important part of DPS-wide strategy, and will benefit all salmonid populations, protecting existing high quality or good quality tributary habitat and restoring degraded habitat will specifically benefit Middle Columbia steelhead populations in the spawning and rearing life stages. Improved spawning and rearing means that more fish will reproduce, more juveniles will survive to migrate, and consequently more adults will return, even if the other factors remain as they are today.

The actions for tributary habitat include the following:

- Implementation of locally developed management unit plans to address protection and restoration of tributary habitat.
- Implementation of Federal, state, and tribal programs, such as, for example, U.S. Forest Service and BLM best management practices for grazing, mining, and recreation, and EPA and tribal programs to implement TMDLs and cold water refugia, in a manner that addresses primary habitat strategies and actions at the local level.

Relatively little information is available concerning Middle Columbia River steelhead use of mainstem Columbia River habitat above Bonneville, aside from passage through the dams. NMFS believes it is important to assess nearshore habitat and cold water refugia in the mainstem and to explore opportunities for, and potential benefits from, restoration and protection of these areas.

7.1.3 Impaired Fish Passage

Problems in migratory corridors for juvenile and adult steelhead in the mainstem Columbia River and tributaries should be addressed to improve survival.

7.1.3.1 Impaired Fish Passage in Mainstem Columbia River

Although the Federal Columbia River Power System (FCRPS) is a major limiting factor for steelhead in the mainstem Columbia River, changing it is a complex process. Three U.S. government agencies – the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (COE) and the Bureau of Reclamation (Reclamation), also called, collectively, the "action agencies" – collaborate to run the FCRPS, under various congressional authorities, as a coordinated system for power production and flood control. The 31 federally owned multipurpose dams on the Columbia and its tributaries that make up the FCRPS provide about 60 percent of the Northwest's hydroelectric generating capacity. The dams supply irrigation water to more than a million acres of land in Washington, Oregon, Idaho and Montana. The river is used for barge navigation from the Pacific Ocean to Lewiston, Idaho, 465 miles inland.

NMFS has statutory responsibility under the ESA to consult with the FCRPS agencies and determine whether FCRPS effects on listed species are likely to jeopardize the continued existence of the species or cause adverse modification of critical habitat. NMFS summarizes its findings in a Biological Opinion, or BiOp. On May 26, 2005, the Federal District Court, in *National Wildlife Federation, et al., vs. National Marine Fisheries Service, et al.,* issued an opinion finding fault with the NMFS 2004 FCRPS BiOp (NMFS 2004). On October 7, 2005, the court ordered a "remand" of the BiOp, requiring NMFS and the three Federal agencies, called the action agencies, to engage in a collaborative process, which included input from affected States and Tribes, to develop proposed operational measures for analysis in a new biological opinion. The court's order, among other things, directed the action agencies to demonstrate how their proposed actions would contribute to recovery. A revised Biological Opinion was issued on May 5, 2008 (NMFS 2008a) and is available at http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/Final-BOs.cfm.

Current Columbia River hydropower programs and operations are the result of this and other completed or ongoing ESA section 7 consultation processes; habitat conservation plans (HCPs) pursuant to ESA section 10; FERC relicensing proceedings and other regulatory processes. In most cases, hydropower programs and operations are intended both to avoid jeopardy to listed species and to contribute to recovery.

The plan for current mainstem hydro operations, as summarized in the Hydro Module (NMFS 2008c), and any further improvements for fish survival that may result from the ongoing FCRPS collaborative process, represent the hydropower recovery strategy for all listed salmonids that migrate through the mainstem Columbia River, including the Middle Columbia steelhead populations.

The Reasonable and Prudent Alternative (RPA) for the FCRPS takes a comprehensive approach to ESA protection that includes hydro, habitat, hatchery, harvest and predation measures to address the biological needs of salmon and steelhead in every life stage. The RPA is the product of the collaboration between NMFS and the action agencies ordered by the court. It is based on a comprehensive analysis of the salmon life cycle conducted down to the level of the populations that make up the listed species. Section 8.8 and the "Reasonable

and Prudent Alternative Table" in the 2008 FCRPS Biological Opinion describe actions that should positively affect Middle Columbia River steelhead.

The current plan for operation of the FCRPS through 2018 (NMFS 2008a) contains the following actions intended to address the needs for survival and recovery of ESA-listed salmon and steelhead:

- Continue adult fish passage operations that have resulted in improved survival.
- Improve juvenile fish passage: install removable spillway weirs or similar surface bypass devices at John Day and McNary dams, an extended tailrace spill wall at The Dalles Dam, and various modifications at Bonneville Dam. Passage for steelhead smolts at each of the four Lower Columbia River mainstem projects must reach 96 percent survival.
- Continue and enhance spill for juvenile fish passage.
- Continue reservoir operations and river flows to benefit spring migrating juveniles.
- Develop dry water year operations to better protect migrating juveniles.
- Develop and implement a kelt management plan.

Dissenting View of State of Oregon Regarding Mainstem Operations

At the time the proposed recovery plan was finalized, August 2008, it was the position of the State of Oregon that additional or alternative actions should be taken in mainstem operations of the FCRPS for ESA-listed salmon and steelhead. Some additional or alternative actions recommended by Oregon, while considered, were not included in NOAA's FCRPS Biological Opinion. At this time, Oregon is a plaintiff in litigation against various federal agencies, including NOAA, challenging the adequacy of the measures contained in the current FCRPS Biological Opinion. NOAA is not in agreement with Oregon regarding the need for or efficacy of Oregon's additional or alternative actions. The actions sought by Oregon include:

- Draft storage reservoirs to help meet weekly and seasonal flow and velocity equivalent objectives for the lower Columbia and Snake rivers.
- Operate reservoirs at rule curves and seek additional flow augmentation volumes from Snake River and Canadian reservoirs for spring and summer flow and velocity objectives.
- Operate John Day reservoir at minimum operating pool (MOP) during spring and summer as long as barge transport and irrigation needs are met.
- Provide spill to total dissolved gas limits of water quality waivers or biological constraints at all dams, except maximize transportation at Snake River collector projects during lowest (10^{th} percentile) flow years.
- Maintain approximately 50/50 in-river and transportation proportions for spring and summer migrants in the Snake River by optimizing spill and surface-oriented routes of dam passage and transporting fish collected in the turbine screen bypass systems. Continue to provide spill and bypass all fish at McNary Dam at all flows during the spring migration period.
- Test removable spillway weirs and temporary spillway weirs to ensure they provide equal or better benefits of full spill before reducing spill.
- Establish more rigorous research, monitoring and evaluation to assure that fish survival is increasing and to inform adaptive management.
- Identify and prepare contingency actions for implementation if necessary to meet fish performance standards linked to the survival and recovery requirements of listed fish.

7.1.3.2 Impaired Fish Passage in Tributaries

Actions to improve fish passage in tributaries include:

- Implement locally developed management unit plans to improve fish passage.
- Implement recommendations regarding improved passage and flow management by the U.S. Bureau of Reclamation below all its facilities in the Yakima River and the Umatilla River subbasins, provision of fish passage into significant tributaries, and provision of passage over at least two of its storage dams in the Yakima Basin[35].
- Implement recommendations regarding improvement of fish passage, screening, and flow management in the Walla Walla River subbasin by the U.S. Army Corps of Engineers, and alteration of the flood operating rule for Mill Creek, or alternatively screening the diversion into Bennington Lake.
- Provide passage into the upper Deschutes River above Round Butte/Pelton complex and into the White Salmon River above Condit Dam according to multiparty agreements.

7.1.4 Hatchery Reforms

Influence from hatchery fish is a limiting factor for the Middle Columbia steelhead DPS because of out-of-basin hatchery fish straying onto natural spawning grounds in the John Day Basin, Deschutes River Eastside and Westside, and the Umatilla and Walla Walla rivers, as well as potential effects of hatchery releases and strays on naturally produced steelhead in the Klickitat subbasin. The hatchery programs in question are managed under the Mitchell Act, the Lower Snake River Compensation Plan, and the *U.S. v. Oregon* process involving the fisheries co-managers, and regulated by NMFS permits and section 7 consultations.

Hatchery reform actions are included in some of the management unit plans, and are also discussed in NMFS' Appendices C and D of the Supplemental Comprehensive Analysis of the FCRPS (NMFS 2008a). Additional actions are expected to be identified through the Hatchery Scientific Review Group's work and in hatchery management plans (e.g., Klickitat River Anadromous Fisheries Master Plan). These hatchery reform proposals will be addressed and implemented through the development of HGMPs, section 7 consultations, and the *U.S. v. Oregon* process.

NMFS is working with the funding agencies and hatchery operators to update and complete Hatchery and Genetic Management Plans (HGMPs) for every hatchery program in the Middle Columbia region, as well as for the hatchery programs that are part of the Lower Snake Compensation Plan and Mitchell Act and have been identified as producing the

[35] The conservation measures in NOAA's 2006 listing decision specifically identify the need for passage at two or more of the storage dams in the Yakima Basin. The Yakima Steelhead Recovery Plan strongly recommends the provision of passage at the storage dams, but notes that the geographic distribution criteria detailed in the plan do provide for combinations of spawning areas that would meet delisting and short-term recovery thresholds without provision of access above the storage dams (See Appendix E, Section 4.3.7)

problematic, out-of DPS hatchery strays. The HGMPs are the basis for NMFS' biological opinions on hatchery programs under sections 7 and 10 and the 4(d) rule, which all relate to incidental and direct take of listed species. The HGMPs describe each hatchery program's operations and the actions taken to support recovery and minimize ecological or genetic impacts, such as straying and other forms of competition with naturally produced fish. The revised FCRPS Biological Opinion (NMFS 2008a) requires the hatchery operators and the action agencies to submit to NMFS updated HGMPs describing site-specific applications of the "best management practices" for the hatchery programs as described in Appendices C and D of the Supplemental Comprehensive Analysis (SCA) of the Biological Opinion for those mitigation hatchery programs funded by the FCRPS action agencies.

Hatcheries are the subject of three major scientific reviews that are expected to provide important information that will be helpful in crafting specific hatchery actions that are consistent with salmon and steelhead recovery: the Mitchell Act Draft Environmental Impact Statement (DEIS) (in production), USFWS Hatchery Review, and the congressionally established Hatchery Scientific Review Group (HSRG). The HSRG recently published its recommendations (HSRG 2009.) Collectively, these scientific reviews will be scrutinizing every anadromous fish hatchery in the Columbia Basin. The schedule for updating hatchery actions is designed to allow consideration of information from the hatchery reviews. The updated HGMPs for programs in the range of the Middle Columbia steelhead DPS are all targeted to be submitted to NMFS in 2009, with section 7 consultations completed in 2010.

Oregon Steelhead Recovery Plan

The Oregon Steelhead Recovery Plan proposes a number of management strategies and actions to address the impacts of strays from hatchery programs outside the DPS that are a source of out-of-DPS strays. These recommendations include increased marking of Columbia Basin hatchery steelhead with coded-wire tags, and requiring mass marking of all hatchery steelhead releases with, at a minimum, an adipose fin-clip. In addition, for the hatchery programs that contribute significantly to the stray problem, develop alternative broodstocks that will stray at lower rates, and reduce the proportion of Snake River hatchery smolts that are transported from Lower Granite and Little Goose dams. Section 9.7.2 identifies proposed tributary hatchery strategies and actions for each population. The Oregon Sounding Board members did not reach consensus on all strategies and actions. For each proposed strategy and action, the Oregon Steelhead Recovery Plan lists the Sounding Board's views, and whether or not consensus was reached on the proposal. NMFS realizes these are regional issues that need to be addressed.

Klickitat Plan

The Klickitat population's moderate risk rating was assigned primarily on the basis of uncertainty and lack of data, particularly with respect to the influence of hatchery fish on the wild steelhead population. The plan recommends a targeted monitoring program to determine abundance and productivity of natural spawners, the proportion of hatchery and wild spawners in the Klickitat subbasin, and the adverse effects of Skamania broodstock on the Klickitat population, if any.

The Yakama Nation is also working with NMFS, WDFW, Tribal fish and wildlife leaders, and others to develop a master plan for an integrated hatchery program for the Lower Klickitat River with the purpose of minimizing adverse impacts on the natural steelhead spawning population. The same entities are considering the possibility of using a conservation hatchery program to accelerate recolonization of the Upper Klickitat watershed, since passage has been restored at Castile Falls. The hatchery program would not occur for at least 9 years after passage was restored, to allow for an evaluation of the natural recolonization management strategy.

Southeast Washington Plan

The Southeast Washington Plan does not propose new actions related to hatcheries but notes that as future hatchery strategies and scenarios are developed by the fisheries co-managers, the needs for achieving harvest objectives should be balanced with the risks to recovery of naturally spawning populations. In the Walla Walla basin, the plan says that the current segregated hatchery program could be transitioned to an integrated one using wild brood stock. For the Touchet River, the plan proposes intensified monitoring to determine whether strays from the segregated program pose an unacceptable risk to the genetic integrity of the natural population, and if so, to eliminate the segregated program. In the short term, both the integrated and segregated programs will be continued with increased monitoring of hatchery fish and removal of hatchery fish at the weir in Dayton. Based on monitoring of the impacts of the segregated program and the success of the integrated program it is anticipated that over the long term only the integrated program would continue.

Yakima Steelhead Plan

The Yakima Steelhead Plan does not indicate hatchery related effects as a limiting factor for steelhead, and states that hatchery steelhead have not been released in the Yakima River system since 1993. However, the plan does propose evaluating the use of small-scale supplementation to restore steelhead to watersheds with good habitat conditions where steelhead are not present or severely reduced because of passage barriers that have been or are being removed. The plan also recommends maintaining and evaluating the existing kelt reconditioning program, which uses hatchery techniques to increase the rate of repeat spawning of wild steelhead adults.

7.1.5 Predation, Competition and Disease

Predation, competition and disease are grouped together as a category of concern because ultimately these factors relate to balance and imbalance in the ecosystem. Improving habitat for salmonids throughout the life cycle is the best strategy for addressing these potential limiting factors (ISAB 2007). Specific measures can also be taken; the following is a summary of ongoing efforts and research.

7.1.5.1 Predation

Extensive research on predation and efforts at predator control, including piscivorous fish, avian predators, and marine mammals have been undertaken in the Columbia Basin for decades, and will continue. The FCRPS BiOp and the Estuary Module (73 FR 161, January 2, 2008), both of which are part of this recovery plan, provide extensive evaluations of these

issues as threats and limiting factors as well as specific strategies and actions for both monitoring and addressing them.

Piscivorous Fish

- Northern Pikeminnow Management Program - A multi-year, ongoing effort funded by BPA to reduce piscivorous predation on juvenile salmon through incentives to sports fishermen to remove predator-sized northern pikeminnow. From 1991 to 1996, three fisheries (sport-reward, dam angling, and gill net) harvested approximately 1.1 million northern pikeminnows greater than or equal to 250 mm fork length. Total exploitation averaged 12 percent (range, 8.1 to 15.5 percent) for 1991 to 1996 (Section 6.2.7.1 in NMFS 2000b). The annual harvest rate has averaged approximately 12 percent in the last few years.
- Non-native piscivores - Other sport fisheries target smallmouth bass, channel catfish, and walleye. However, the ISAB report states that state fisheries agencies in Washington, Oregon, and Idaho have simultaneously adopted management policies that in some cases seem aimed at perpetuating or even enhancing populations of these introduced predators. The ISAB recommends that the state agencies relax (or eliminate) fishing regulations that may be enhancing populations of non-native species (both predators and competitors), especially those that directly or indirectly interact with juvenile and adult salmonids (ISAB 2007). NMFS supports strategies and actions that would result in reduced populations of non-indigenous predators on juvenile steelhead.

Avian predation

- Altering Rice Island to prevent tern and cormorant nesting was effective in reducing avian predation in the estuary, and the current FCRPS Biological Opinion (NMFS 2008a) recommends further reduction in bird habitat on East Sand Island.
- The Biological Opinion also recommends development of plans to control Caspian terns and double-crested cormorants that nest in islands upstream of Bonneville Dam. The Army Corps of Engineers takes various "avian deterrent actions" at the lower Snake and Columbia River dams, and will continue to do so.

Marine Mammals

A pinniped hazing program has been implemented at Bonneville Dam since 2005, but the efforts have largely been ineffective against California sea lions, which are not listed as threatened or endangered. The animals may leave the area temporarily but return as soon as hazing stops. Under section 120 of the Marine Mammal Protection Act, states can ask for permission to kill individually identifiable sea lions or seals that are having a "significant negative impact" on at-risk salmon and steelhead, and NMFS can grant that permission, if certain legal standards are met. In March 2008, NMFS granted the request of the states of Oregon, Washington, and Idaho to lethally remove problem California sea lions. Any animals that are captured may be euthanized if no permanent holding facility can be found for them. NMFS and representatives of zoos and aquariums are compiling a list of pre-approved permanent holding facilities interested in receiving a limited number of captured sea lions as an alternative to euthanasia. NOAA has authorized the states to remove as many

as 85 animals annually, but estimates that only about 30 animals will be removed each year, given the conditions in its authorization.

In addition, non-lethal deterrence methods will be continued, including the following:

- Vessel chasing
- Cracker shells
- Aerial pyrotechnics (screamer rockets, banger rockets)
- Rubber projectiles
- Sea-lion exclusion devices
- Acoustic deterrents
- Underwater firecrackers
- Capture, marking, and relocation
- Temporary captive holding

Safety and training requirements for vessel use and deterrence measures (including firearms use) also would be continued.

Maintaining and restoring habitat

The ISAB report indicates that the methods of controlling non-native piscivores have not been sufficient, and that maintaining and restoring habitat is actually the better strategy. "When native species are provided with habitat for which they are best adapted, they have an improved chance of out-competing or persisting with non-native species," the ISAB report states (ISAB 2008). NMFS, as indicated elsewhere in this chapter, supports that conclusion.

Research and monitoring

NMFS supports the recommendations in the Yakima Steelhead Plan for research and monitoring to track trends in predator populations, understand their impacts on steelhead, and develop appropriate management techniques to reduce predation.

7.1.5.2 Competition – Density Dependent Mortality

As described in Section 6.3.5.4 of this Plan, density-dependent mortality can occur at any stage in salmon or steelhead life cycle and may be exacerbated by the introduction of, and/or cumulative effects of, large numbers of hatchery fish released over a relatively short period of time. Consistent with this concern NMFS, Salmon Recovery Division, and the Northwest Fisheries Science Center are planning to better define and describe the scientific uncertainty associated with ecological interactions of hatchery-origin and natural-origin salmonids. See also Appendix C of the 2008 FCRPS Biological Opinion (NMFS 2008a).

7.1.5.3 Disease

Disease in salmonids is caused by multiple factors and probably cannot be directly addressed by recovery actions except in specific instances of known causal factors. It is more likely that nearly all of the recommended recovery actions that improve spawning, rearing, and passage conditions for steelhead and increase the survival, abundance, and productivity of naturally produced fish will result in decreasing incidence of disease.

7.1.6 Harvest

Although in general harvest is not considered a major threat for the Middle Columbia steelhead DPS, it is important to ensure that impacts from fisheries do not impede recovery, and to perform monitoring and evaluation to verify impacts and reduce existing uncertainties.

- The *U.S. v. Oregon* agreement for 2008-2018 will maintain current low impacts on Middle Columbia steelhead in the lower mainstem and treaty mainstem fisheries. (See Section 6.3.7)
- The Fisheries Management and Evaluation Plans (FMEPs) submitted by the States of Oregon and Washington and approved by NMFS under the 4(d) rule of the ESA provide a mechanism for developing, implementing, and adjusting recreational fisheries to achieve management and conservation objectives. Under the FMEPs, recreational fisheries in the tributaries are expected to maintain the currently estimated low impacts on steelhead. Furthermore, NMFS requires the states to implement, monitor, and evaluate the effects of these plans and to report annually, including an assessment of the annual catch of natural fish, fishery mortality, the abundance of hatchery and natural fish for each tributary fishery area, and angler compliance. A comprehensive evaluation is required every five years. The continuing and additional monitoring and evaluation under the FMEPs is expected to further reduce uncertainties concerning fisheries impacts.
- Other increases in monitoring and evaluation will help to reduce uncertainties concerning fisheries impacts on steelhead:
    - Creel surveys or other methods of quantifying impacts in the more popular fisheries
    - In-basin monitoring of escapement from ocean into tributaries and onto the spawning grounds
    - Monitoring to verify the applicability of aggregate impact rates of mainstem fisheries on specific populations
- Other proposals in the management unit plans:
    - The Oregon Steelhead Recovery Plan proposes using selective fisheries to reduce the number of out-of-basin hatchery strays.
    - The Washington Gorge Management Unit plans recommend studies to determine the impacts of tributary fisheries and to determine the extent of illegal harvest, if any.

7.1.7 Estuary and Columbia River Plume

Although juvenile steelhead pass through the estuary on their way to the ocean, they tend to spend less residence time in the shallow parts of the estuary than other salmonids, and therefore the characteristics of the Columbia River plume and the deeper channels of the estuary are more important in determining their survival.

Flow changes in the estuary are primarily a result of dam operations, whereas habitat changes are a function of both hydropower operations and other, non-hydro issues, notably the

construction of dikes and levees in the estuary. The main effects of flow on Middle Columbia steelhead populations are associated with changes in the plume. Thus, actions that affect the plume, decrease exposure to toxicants, and decrease predation (especially Caspian tern predation) should improve the abundance/productivity and diversity of the Middle Columbia DPS.

NMFS' Estuary Module identifies 23 types of management actions that would improve estuary conditions for all salmonids. The following is a selection of these actions most beneficial to steelhead:

- Adjust the timing, magnitude and frequency of flows (especially spring freshets) entering the estuary and plume to provide better transport of sediments and access to habitats in the estuary, plume, and littoral cell.
- Manage pikeminnow, smallmouth bass, walleye, and channel catfish to prevent increases in abundance.
- Identify and implement actions to reduce salmonid predation by pinnipeds.
- Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.
- Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.
- Implement pesticide and fertilizer best management practices to reduce estuary and upstream sources of toxic contaminants entering the estuary.
- Identify and reduce industrial, commercial, and public sources of pollutants.
- Monitor the estuary for contaminants and/or restore contaminated sites.
- Implement stormwater best management practices in cities and towns.

The module includes an evaluation of the "constraints" on implementation of these actions. Perhaps the most significant action would be to adjust the timing, magnitude and frequency of flows to return to a more natural hydrograph for the estuary; however, this is the least possible of the actions, given the constraints:
Constraints on hydrosystem operations prevent the return to a natural hydrograph in the estuary. Implementation of this action would be limited by international treaties, the need for flood control, fish management objectives systemwide, and power management (NMFS 2007).

7.1.8 Climate Change

A strategy for addressing the effects of climate change on Middle Columbia River steelhead needs to be based, broadly, on the principle of preserving biodiversity. Diversity in terms of both location and biological characteristics gives any species resilience in the face of environmental change. This principle underlies the viability criteria presented in Chapter 3 of this plan, as well as the strategies described in this chapter to address the factors limiting steelhead viability, as these are currently understood. NMFS supports the ISAB's recommendations for mitigating the effects of climate change (ISAB 2007), most of which are encompassed in Section 7.2 of this Plan.

The ISAB notes that "As climate and streams warm, tributary habitats will become increasingly important because they usually provide the cool waters for salmonids and other cool-water species in a watershed" (ISAB 2007). It follows that water temperature and stream flow are factors that will remain important throughout steelhead freshwater habitat. All strategies and actions that help to lower water temperature or prevent further increase will help to mitigate climate change. Protecting and/or restoring riparian areas to increase shade, as recommended in Section 7.2, is an important strategy for minimizing water temperature increases. Additional actions include purchasing water rights to leave more water in streams and restoration actions to improve channel complexity and establish side-channel rearing (FCRPS BiOp, NMFS 2008a). Specific recommendations from the ISAB include:

- Protect or restore riparian buffers along streams – especially in headwater tributaries where shading is crucial for maintaining cool water temperatures.

- Expand efforts to protect riparian areas from grazing, logging, development, or other activities that could impact riparian vegetation.

- Protect potential thermal refugia. Remove barriers to fish passage into thermal refugia.

The ISAB emphasizes the importance of identifying areas that may be most affected by climate change and establishing adequate protective measures, including "reserve" areas or strongholds of high productivity and diversity.

The ISAB also offers possible actions that could be taken on the mainstem Columbia River to address climate change impacts on Middle Columbia steelhead:

- Flow augmentation from cool/cold water storage reservoirs to reduce water temperatures or create cool water refugia in mainstem reservoirs and the estuary. Effective implementation of this strategy may require increasing the number of storage reservoirs.

Existing FCRPS operations result in cold water releases from Dworshak reservoir in late summer. Temperature control towers at other headwater reservoirs are under consideration through other processes. However, these actions are unlikely to have a significant impact on Middle Columbia steelhead because these water sources are too far away from this species' migration corridor. For Middle Columbia steelhead, new reservoirs would be needed in order to implement this option. Careful consideration of the benefits and negative impacts of increasing the number of storage facilities in the basin will be required. Such consideration should occur in the near future if storage capacity is to be increased in time to address climate change impacts.

- Use of removable surface weirs to reduce the time juvenile salmonids spend in the warm water of the forebay.

This Recovery Plan (through the FCRPS BiOp) includes operating all mainstem dams with removable surface weirs or other structures to quickly move juveniles downstream from dam forebays.

- Reduction of water temperatures in the ladders with water drawn from lower, cooler strata in the water column of the forebay.

Most mainstem reservoirs that Middle Columbia steelhead pass are isothermal during warm water periods, so pumping water from depth would not reduce ladder temperatures. However, stratification with warm surface water affecting fish ladders sometimes occurs at McNary Dam. A means of cooling fish ladder temperatures at this project should be investigated.

- Liberalization of harvest of introduced piscivorous species such as smallmouth bass, walleye, and channel catfish.

The recovery plan (through the FCRPS BiOp) calls for a plan to reduce predation of introduced fish species by the end of 2009.

- There are opportunities to mitigate for some climate change impacts in the estuary and plume with changes to hydrosystem operations. Possible actions would include reducing the frequency and magnitude of winter flows, extending the period of spring runoff later in the year, and increasing late summer and autumn flows.

The recovery plan (through the FCRPS BiOp) calls for estuary habitat restoration projects that include dike breaching and restoring access and tidal influence to marshes.

The recovery plan (through the FCRPS BiOp) includes new analyses to incorporate climate change predictions into mainstem Columbia River hydrology models with improved forecasting capabilities. The goal is better long-term operations planning, including patterns of reservoir storage and release for flood control and other purposes.

Climate change responses require significant monitoring information and additional research regarding effects of climate on key habitat variables and effects of habitat variables on fish survival. Research and monitoring related to climate change are described in Section 10.3.2.

7.1.9 Coordination/Governance

Coordination of actions and information-sharing among fisheries biologists, Tribes, local governments, citizen groups, and state and Federal agencies based in both Oregon and Washington is a key component of recovery for this DPS. Benefits of coordination include:

- Dealing with shared migration areas consistently.
- Developing coherent MPG-level strategies where populations are in two states (Cascades Eastern Slope MPG; Umatilla/Walla Walla MPG), or the same population is in both states (Walla Walla population).
- Promoting consistent methods for setting recovery objectives, evaluating strategies, and monitoring progress across populations, MPGs, and the DPS.

This coordination is under development. The recent creation of a Middle Columbia Recovery Forum, to be convened regularly by NMFS, is intended to facilitate such collaboration between scientists and recovery planners on both sides of the Columbia River. The Middle Columbia Recovery Forum is discussed further in Chapter 11, Implementation.

7.1.10 Research, Monitoring and Evaluation and Adaptive Management

An important part of the strategy for achieving recovery is the development of a monitoring plan that will support implementation of the recovery plan and long-term adaptive management in response to changes and trends in the data. Two keys to effective implementation are targeting actions to specific areas and monitoring the results of the actions. To achieve these goals, a scientific technical team made up of local scientists, former ICTRT members, and managers will be necessary. The monitoring plan is discussed in more detail in Chapter 10.

For each DPS-level, five-year status review, NMFS needs summarized information on each population derived from more detailed field assessments – at the least, monitoring data on abundance and productivity throughout the steelhead's range. The most efficient way to generate this information is through annual reports compiled by regional biologists. Currently, although basic data (e.g., redd surveys) are being gathered, funding and staff are lacking to turn this raw data into annual estimates of abundance/productivity in each river or stream in a timely fashion. Typically, each five-year status review starts with a time-consuming scramble to gather the information from the regional biologists and work with them to produce the metrics that are needed for the status assessment. These annual reports need to be funded, staffed, and standardized.

The Southeast Washington Plan proposes that the co-managers should be convened with NMFS and USFWS to better define the level (scale, frequency, location) of monitoring required to determine when recovery goals are achieved. The results of these conversations could be used to better define monitoring tasks and allow for the prioritization of expenditures.

In addition to the issue- and area-specific monitoring for adaptive management, research should be directed toward resolving the many uncertainties pertaining to ocean productivity, global climate change, hatchery effectiveness, effects of transportation, invasive species, effects of interacting strategies, and effects of human population growth on steelhead recovery. These are described in greater detail in Section 10.3 of this Plan.

7.2 Summary of Recovery Strategies for the MPGs

The following sections summarize the recovery strategy for each MPG. Tables 7-1 through 7-4 show more detail. The tables link the strategies with the limiting factors addressed.

7.2.1 Cascades Eastern Slope Tributaries MPG

Population	ICTRT Risk Status
Fifteenmile Creek	Viable
Deschutes Eastside	Viable
Klickitat	(provisional) Moderate risk – insufficient data, hatchery influence
Rock Creek	(provisional) High risk – insufficient data
Deschutes Westside	High risk
White Salmon	Functionally extirpated
Crooked River	Extinct

Two populations in this MPG meet the criteria for viable status (Fifteenmile Creek and Deschutes Eastside); one (Klickitat) is assigned a provisional moderate risk ("maintained" status) based on insufficient abundance/productivity data and an unknown degree of diversity risk from hatchery influence; one (Rock Creek) is assigned a provisional high risk status because of lack of data; one (Deschutes Westside) is at high risk for abundance/productivity and moderate risk for spatial structure/diversity, primarily because of blocked passage to a large amount of historically accessible habitat. Two populations in the MPG are extirpated (White Salmon and Crooked River); the Crooked River population was historically very large.

Recovery Scenario: For the Cascades Eastern Slope Tributaries MPG to be considered viable based on the currently extant populations, the Klickitat, Fifteenmile, and both the Deschutes Eastside and Westside populations should reach viable status, with one highly viable. The Rock Creek population should reach "maintained" status (25 percent or less risk level). MPG viability could be further bolstered if reintroduction of steelhead into the Crooked River succeeds and if the White Salmon population is successfully reintroduced to its historical habitat.

Gap: The median survival gap (assuming recent ocean and base hydrosystem conditions and 5 percent risk) for the Cascades Eastern Slope MPG is 0.21 (meaning that a 21 percent increase in average life-cycle survival is required to achieve 5 percent risk in a 100-year time period). The gap ranges from –0.34 (Deschutes Eastside) (no gap) to 0.78 (Deschutes Westside) (needs 78 percent improvement). There was not enough information to estimate gaps for the Klickitat or Rock Creek populations.

Key actions proposed (more detail in Table 7-1):

- Protect, improve, and increase freshwater habitat for steelhead production. Improvements to freshwater habitat should be targeted to address specific limiting factors in specific areas as described in the Oregon Steelhead Recovery Plan and the Washington Gorge plans.
- Reduce straying of out-of-DPS hatchery fish onto natural spawning grounds within the Deschutes subbasin.

- Restore historical passage to the upper Deschutes subbasin including the Westside tributaries and Crooked River above Pelton Round Butte dam complex and the White Salmon River above Condit Dam.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007) and FCRPS Biological Opinion (NMFS 2008a).
- Improve hatchery management to minimize impacts from hatchery releases on naturally produced steelhead within the Deschutes West and East and Klickitat subbasins.
- Fill data gaps for better assessment of Klickitat and Rock Creek steelhead populations.
- Coordinate between scientists, planners, and implementers of recovery actions on both sides of the river for sequencing of recovery actions and monitoring for adaptive management.

Summary of MPG Recovery Strategy: The proposed actions for the five extant populations in the Cascades Eastern Slope MPG are based on restoring important tributary habitat functions in areas that likely supported substantial steelhead production. The particular actions proposed for each population are predicated upon restoring natural conditions supporting summer rearing and overwintering in high potential reaches. For Cascades Eastern Slope populations, restoring degraded instream channel structure and the associated riparian habitats is a common element. For several populations, restoring sufficient flow, addressing high summer water temperatures, and other water quality issues are also key components. Quantitative modeling indicates that achieving the targeted levels of habitat improvement will translate into increases in both juvenile production capacity and survival rates through the key summer and winter juvenile rearing periods. Restoring access to tributaries with substantial amounts of high quality habitat is also a high priority across populations. Current and future increases in steelhead production from tributary habitats will be further bolstered by actions aimed at reducing mortalities during juvenile and adult migrations to and from the ocean.

The specific tributary habitat strategy for each population builds out from good habitat, targeting opportunities where there is substantial habitat potential. For the Fifteenmile Creek, Deschutes (eastside), Deschutes (Westside) and Rock Creek populations, restoring stream structure, riparian habitat, and water quality (temperature, sediments, etc.) in the lower reaches of major tributaries and the associated population mainstems are identified as high priorities. In the Klickitat, recent passage improvements at Castile Falls have reduced impediments to steelhead access into a substantial amount of habitat in the upper Klickitat River. Restoring stream channel structure and diversity and addressing tributary access problems in the Upper Klickitat is highlighted in the plan. Unique to the Westside Deschutes River population is a major effort to restore upstream and downstream passage at the Pelton/Round Butte Complex. This passage restoration combined with reintroductions using hatchery fish is designed to reestablish natural production in the blocked areas in the Westside population and in the extirpated Crooked River population. Section 9.7.2 in the Oregon Steelhead Recovery Plan gives details for these actions (ODFW 2009).

The recovery strategy for the two Deschutes River populations involves reducing the impacts and risks associated with chronically high levels of non-local stray hatchery spawners. While direct estimates of impacts on these particular populations are not available, steelhead field studies in nearby drainages and modeling of the proposed actions indicate that natural productivity may be significantly impaired, especially given the abundance of strays. The current steelhead hatchery program in the Klickitat River is intended to be a segregated program; an important objective is to minimize spawning interactions with natural-origin spawners. The Klickitat River strategy includes evaluating the performance of the current programs in the Klickitat (steelhead, Chinook and coho), adjusting to complement natural recovery efforts, and considering the use of artificial production in restoring production above Castile Falls.

An important element across all of the Middle Columbia steelhead populations is to continue to manage harvest in a manner that supports recovery efforts. Middle Columbia steelhead runs are subject to harvest in mainstem Columbia River fisheries and in hatchery-directed tributary fisheries. Fisheries in each of those geographic areas are currently managed under impact limits for natural-origin steelhead and all recreational fisheries prohibit retention of natural-origin fish.

Results of modeling management action effectiveness indicate that for most of the populations in the Cascades Eastern Slope Tributaries MPG, most of the productivity and capacity benefits from the proposed recovery actions will result from those focused on tributary habitat.

Table 7-1 Recovery Strategies and Actions for the Cascades Eastern Slope Tributaries MPG.

CASCADES EASTERN SLOPE TRIBUTARIES MPG				
Strategies (Not necessarily in order)	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
Tributary Habitat				
Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	All populations in MPG	• Protect highest quality habitats through acquisition and conservation. • Adopt and manage Cooperative Agreements. • Conserve rare and unique functioning habitats. • Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	All Parameters	Degradation of tributary habitat-forming processes and functions (loss of channel structure, floodplain connectivity, riparian vegetation and LWD recruitment)
Restore passage and connectivity to habitats blocked or impaired by artificial barriers.	Deschutes Westside Deschutes Eastside Crooked River Fifteenmile Creek White Salmon River Klickitat River Rock Creek	• Provide passage at Condit Dam. • Provide passage at Pelton-Round Butte Complex (PRBC). • Provide passage at Pine Creek confluence with Columbia River. • Improve steelhead passage at Lyle Falls Fishway. • Remove or replace barriers blocking or impairing passage including dams, dikes, road culverts and irrigation structures. • Provide screening at 100% of irrigation diversions. • Replace screens that do not meet criteria.	Abundance, Productivity, Spatial Structure	Loss of historical habitat because of blocked or impaired fish passage (dams, culverts, seasonal push-up dams, unscreened diversions)
Restore floodplain connectivity and function.	Fifteenmile Creek Deschutes Westside Deschutes Eastside White Salmon River Klickitat River Rock Creek Major Creek	• Reconnect side channels and off-channel habitats to stream channels. • Restore wet meadows. • Reconnect floodplain to channel. • Relocate or improve floodplain infrastructure and roads.	Abundance, Productivity, Spatial Structure	Degraded floodplain connectivity and function (loss of off-channel habitat, side channels and connected hyporheic zone)
Restore channel structure and complexity.	Fifteenmile Creek Deschutes Westside Deschutes Eastside White Salmon River Klickitat River Rock Creek Major Creek	• Place stable wood and other large organic debris in streambeds. • Stabilize stream banks. • Restore natural channel form.	Abundance, Productivity	Degraded channel structure and complexity (loss of spawning and rearing habitat, LWD, pools)
Restore riparian condition and LWD recruitment .	Fifteenmile Creek Deschutes Westside Deschutes Eastside White Salmon River Klickitat River Rock Creek Major Creek	• Restore natural riparian vegetative communities. • Develop grazing strategies that promote riparian recovery.	Abundance, Productivity	Degraded riparian condition (native riparian vegetative communities, LWD recruitment)

CASCADES EASTERN SLOPE TRIBUTARIES MPG				
Strategies (Not necessarily in order)	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
Restore altered hydrograph to provide appropriate flows during critical periods.	Fifteenmile Creek Deschutes Westside Deschutes Eastside Crooked River White Salmon River Klickitat River Rock Creek	• Implement agricultural water conservation measures. • Improve irrigation conveyance and efficiency. • Lease or acquire water rights and convert to instream. • Restore natural functions and processes through actions identified in strategies above. • Employ BMPs for forest, agriculture and grazing practices and road management. • Protect and/or rehabilitate springs.	Abundance, Productivity	Altered hydrology (low summer flow, scouring peak flows due to degraded watershed conditions and/or streamflow alterations and withdrawals for irrigation and other uses)
Improve degraded water quality.	Fifteenmile Creek Deschutes Westside Deschutes Eastside Crooked River White Salmon River Klickitat River Rock Creek	• Reduce chemical pollution inputs. • Restore natural functions and processes through actions identified in strategies above. • Employ BMPs for forest, agriculture and grazing practices and road management. • Upgrade or remove problem forest roads. • Conduct pathogen sampling and monitoring. • Construct water and sediment control basins.	Abundance, Productivity	Degraded water quality (abnormal temperatures or fine sediment, nutrients from runoff, pesticides and other chemicals, and/or degraded because of water withdrawals that reduce natural stream flows)
Harvest				
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	All populations in MPG	• Maintain current management regulations for low impact fisheries and adjust tributary harvest regulations in areas where harvest significantly impacts steelhead viability. • Monitor and evaluate effects of tributary harvest.	Abundance, Productivity	Not a primary limiting factor.
Use harvest to reduce abundance and proportion of stray hatchery spawners.	Deschutes Westside Deschutes Eastside	• Develop educational outreach program to promote retention of hatchery fish in selective recreational fisheries to reduce the number of out-of-basin hatchery strays.	Abundance, Productivity, Diversity	Straying of Out-of-DPS hatchery fish into natural spawning areas.
Reduce illegal harvest on ESA- listed species.	Klickitat River	• Eliminate illegal harvest by enforcing sport and Tribal regulations.	Abundance, Productivity	Not a primary limiting factor.
Provide better educational opportunities at the COE Park to preventing accidental catch of steelhead.	Rock Creek	• Increase outreach efforts to reduce the number of steelhead caught in recreational fisheries near the mouth of Rock Creek.	Abundance, Productivity	Not a primary limiting factor.
Hatchery				
Determine origin of hatchery strays and increase ability to recognize hatchery-origin fish.	Potential risk for all populations in MPG. Currently a significant risk to Deschutes Eastside and Deschutes Westside populations.	NOTE: The following measures are recommended in one or more management unit plans but have not been agreed upon by all co-managers. - Implement representative coded-wire-tagging (CWT) program so that all hatchery stocks have adequate	Diversity, Productivity	Straying of Out-of-DPS hatchery fish into natural spawning areas.

CASCADES EASTERN SLOPE TRIBUTARIES MPG				
Strategies (Not necessarily in order)	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
		CWT groups released annually. - Mark all hatchery steelhead releases in Columbia River Basin with, at a minimum, an adipose fin-clip. (An exception may be the proposed Klickitat hatchery program – a conservation hatchery program – that may use elastomer eye marking for evaluations.) - Recommend development of alternative broodstocks to reduce stray rates for programs that contribute significantly to stray problem. - Reduce proportion of Snake River hatchery smolts transported from Lower Granite and Little Goose dams.		
Reduce uncertainty in abundance and proportion of hatchery strays spawning naturally.	Fifteenmile Creek Deschutes Eastside Klickitat River, Rock Creek	• Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys and other methods.	Diversity, productivity	Out-of-DPS and Inside-DPS hatchery strays in tributary natural spawning grounds
Reduce abundance and proportion of stray hatchery fish that spawn naturally.	Deschutes Eastside Deschutes Westside	• Construct, improve trapping facilities and expand operations.	Abundance, Productivity, Diversity	Out-of-DPS and Inside-DPS hatchery strays in tributaries
Reduce genetic risks associated with Round Butte Hatchery Program.	Deschutes Westside	• Investigate opportunities and risks associated with incorporating naturally produced Deschutes River summer steelhead into Round Butte Hatchery (RBH) broodstock.	Diversity	Not a primary limiting factor
Restore natural production into historically utilized habitats, including blocked areas above Pelton-Round Butte Complex (Deschutes), Condit Dam (White Salmon) and Castile Falls (Klickitat).	Deschutes Westside Crooked River Klickitat River White Salmon River	• Develop plan for steelhead reintroductions into historical habitat when passage is restored. • Re-establish natural production in MaSAs and some minor spawning areas.	All Parameters	Not a primary limiting factor
Review effect of current hatchery practices and releases.	White Salmon River Klickitat River	• Review potential impact of Skamania stock steelhead on naturally producing steelhead.	Abundance, productivity, diversity	Not a primary limiting factor

7.2.2 John Day River MPG

Population	ICTRT Risk Status
North Fork John Day	Highly viable
Upper Mainstem John Day	Moderate risk
Lower Mainstem John Day	Moderate risk
Middle Fork John Day	Moderate risk
South Fork John Day	Moderate risk

This MPG does not meet viability criteria despite the fact that one of its populations, the North Fork John Day, is the only steelhead population in the Middle Columbia DPS classified as highly viable. The other four populations in the MPG are at maintained status. Both the Upper and Lower Mainstem John Day populations have moderate risk for diversity because of out-of-DPS hatchery strays. The Middle Fork population has moderate risk because of low abundance. The South Fork population has moderate risk for abundance and productivity, and there is also some uncertainty concerning the proportion of hatchery strays spawning.

Recovery Scenario: For the John Day River MPG to reach viable status, the Lower Mainstem John Day River, North Fork John Day River, and either the Middle Fork John Day River or Upper Mainstem John Day River populations should achieve viable status, with one highly viable.

Gap: The median survival gap for the John Day MPG is 0.09, ranging from –0.49 (North Fork) (no gap) to 0.34 (South Fork) (needs 34 percent improvement in average survival over the life cycle).

Key Actions proposed (more detail in Table 7-2):

- Protect and improve freshwater habitat conditions and connectivity for steelhead production. Improvements to freshwater habitat should be targeted to address specific factors in specific areas as described in the Oregon Steelhead Recovery Plan.
- Improve hatchery management to reduce straying from out-of-DPS hatchery fish onto natural spawning grounds within the John Day subbasin.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007) and FCRPS Biological Opinion (NMFS 2008a).

The Oregon Steelhead Recovery Plan identifies priority areas and actions for each population based on relative importance in meeting local and regional recovery objectives, and envisions local groups using the individual population action tables for development of specific implementation plans.

Summary of MPG Recovery Strategy: John Day River steelhead populations have been affected by changes across all the types of habitat they use in their complex life histories and across all their life stages. Of particular importance is the loss of rearing habitat quality and floodplain channel connectivity in the lower sections of major tributaries. Poor conditions in the downstream migration corridors affect both outmigrating juveniles and returning adults. For some populations, increased sedimentation and altered flow regimes have resulted in

increased mortality during incubation and early rearing. Higher summer water temperatures have significantly reduced the available rearing habitat.

Recovery strategies for John Day steelhead are designed to improve conditions across the range of habitats used for spawning, rearing, and migration. Actions projected to contribute the most would restore or maintain rearing habitat complexity and address sediment and temperature problems, especially in reaches that are adjacent to high quality habitats. Restoration of the associated riparian habitats will also contribute to sustaining natural stream functions. These actions will reduce sediment, restore a more normal hydrograph, and reduce water temperature. In addition, there are a significant number of actions to improve passage and connectivity of habitats for both juvenile and adult life stages.

The effect of improved tributary habitat will be enhanced if, in addition, migration conditions in the mainstem Columbia River and estuary are improved, fewer outside-origin hatchery fish spawn within the basin, and harvest is managed so that a high proportion of the increased numbers of steelhead return to spawn.

Table 7-2 Recovery Strategies and Actions for the John Day River MPG.

JOHN DAY RIVER MPG				
Strategies	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
Tributary Habitat				
Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	All populations in MPG	• Protect highest quality habitats through acquisition and conservation. • Adopt and manage Cooperative Agreements. • Conserve rare and unique functioning habitats. • Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	All Parameters	Degradation of tributary habitat-forming processes and functions (loss of channel structure, floodplain connectivity, riparian vegetation and LWD recruitment)
Restore passage and connectivity to habitats blocked or impaired by artificial barriers	All populations in MPG	• Remove or minimize use of push-up dams. • Remove or replace barriers blocking passage. • Provide screening at 100% of irrigation diversions. • Replace screens that do not meet criteria. • Improve passage at culverts on forest land.	Abundance, Productivity, Spatial Structure	Loss of historical habitat because of blocked or impaired fish passage (push-up dams, culverts, unscreened diversions)
Restore floodplain connectivity and function	Lower Main John Day South Fork John Day Upper Main John Day	• Reconnect side channels and off-channel habitats to stream channels. • Restore wet meadows. • Reconnect floodplain to channel.	Abundance, Productivity, Spatial Structure	Degraded floodplain connectivity and function (loss of off-channel habitat, side channels and connected hyporheic zone)
Restore channel structure and complexity	All populations in MPG	• Place stable wood and other large organic debris in streambeds. • Stabilize stream banks. • Restore natural channel form.	Abundance, Productivity	Degraded channel structure and complexity (loss of spawning and rearing habitat, LWD, pools)
Restore riparian condition and LWD recruitment	All populations in MPG	• Restore natural riparian vegetative communities. • Develop grazing strategies that promote riparian recovery. • Install/maintain fencing.	Abundance, Productivity	Degraded riparian condition (native riparian vegetative communities, LWD recruitment)
Restore altered hydrograph to provide appropriate flows during critical periods	All populations in MPG	• Implement agricultural water conservation measures. • Improve irrigation conveyance and efficiency. • Lease or acquire water rights and convert to instream. • Restore natural functions and processes through actions identified in strategies above. • Employ BMPs to forest, agriculture and grazing practices and to road management.	Abundance, Productivity	Altered hydrology (low summer flow, scouring peak flows due to degraded watershed conditions and/or streamflow alterations and withdrawals for irrigation and other uses.)
Improve degraded water quality	All populations in MPG	• Reduce chemical pollution inputs. • Reduce discharge from mining and dredging areas.	Abundance, Productivity	Degraded water quality (abnormal temperatures or fine sediment, nutrients from runoff, pesticides and

JOHN DAY RIVER MPG				
Strategies	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
		• Restore natural functions and processes through actions identified in strategies above. • Employ BMPs to forest, agriculture and grazing practices and to road management.		other chemicals, and/or degraded because of water withdrawals that reduce natural stream flows)
Harvest				
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	All populations in MPG	• Maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	Abundance, Productivity	Not a primary limiting factor
Use harvest to reduce abundance and proportion of stray hatchery spawners.	All populations in MPG	• Develop educational outreach program to promote retention of hatchery fish in selective recreational fisheries to reduce the number of out-of-basin hatchery strays.	Abundance, Productivity, Diversity	Straying of out-of-basin hatchery fish into natural spawning areas
Reduce catch and release mortality on natural-origin fish	All populations in MPG	• Promote voluntary curtailment of fishing at higher water temperatures (above 21°C) to reduce hook-and-release mortality.	Abundance, Productivity	Not a primary limiting factor
Improve quality of harvest and natural-origin fish data.	All populations in MPG	• Expand the creel surveys to monitor fisheries effort and catch.	Abundance, Productivity	Not a primary limiting factor
Hatchery				
Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish.	Potential risk for all populations in MPG. Currently a primary risk to Lower John Day population.	NOTE: The following measures are recommended in one or more management unit plans but have not been agreed upon by all co-managers. - Implement representative coded-wire-tagging (CWT) program so all hatchery stocks have adequate CWT groups released annually. - Mark all hatchery steelhead releases in Columbia River Basin with, at a minimum, an adipose fin-clip. - Recommend development of alternative broodstocks to reduce stray rates for programs that contribute significantly to stray problem. - Reduce proportion of Snake River hatchery smolts that are transported from Lower Granite and Little Goose dams.	Productivity, Diversity	Straying of Out-of-DPS hatchery fish into natural spawning areas.
Reduce uncertainty in abundance and proportion of hatchery strays spawning naturally	Potential risk for all populations in MPG. Currently a primary risk to Lower John Day population.	• Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys and other methods.	Productivity, Diversity	Out-of-DPS and Inside-DPS hatchery strays in tributary natural spawning grounds

7.2.3 Umatilla/Walla Walla MPG

Population	ICTRT Risk Status
Umatilla River	Moderate Risk
Walla Walla River	Moderate Risk
Touchet River	High Risk (provisional because of insufficient data)

This MPG does not meet viability criteria because all three populations have moderate risk for both abundance/productivity and spatial structure/diversity and are assigned "maintained" status. The annual abundance data series for the Touchet River steelhead population is relatively short and has several missing years; the ICTRT cautions that the Touchet's status/risk rating is provisional and should be interpreted with caution.

Recovery Scenario: For the Umatilla/Walla Walla MPG to be viable, two populations should meet viability criteria, and of these one should be highly viable. The Umatilla River is the only large population, and therefore should be viable. Either the Walla Walla River or Touchet River population also should be viable.

Gap: There was sufficient information available to estimate gaps for only two of the three populations within the Umatilla/Walla Walla MPG. Assuming base hydrosystem and recent ocean conditions, the survival gaps for the Umatilla and Walla Walla populations are 0.09 and 0.34, respectively.

Key actions proposed (more details in Table 7-4):

- Coordinate between planners, scientists and those implementing recovery actions in Washington and Oregon for sequencing, monitoring, and adaptive management.
- Protect and improve freshwater habitat conditions and access for steelhead production. Improvements to freshwater habitat should be targeted to address specific factors in specific areas as described in the Southeast Washington Plan and the Oregon Steelhead Recovery Plan.
- Improve hatchery management to reduce straying from out-of-DPS hatchery fish onto natural spawning grounds within the Umatilla/Walla Walla subbasins.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007) and FCRPS Biological Opinion (NMFS 2008a).

Summary of MPG Recovery Strategy: Natural steelhead production from the three populations in this MPG are projected to benefit from the combined effects of improved tributary habitats and enhanced survival through the migration corridor connecting upper tributary rearing habitats with the ocean. Tributary restoration strategies in these three populations put a high priority on building out from existing reaches of relatively good spawning and rearing habitat in the upper ends of major tributaries. The downriver tributary reaches targeted for restoration include a substantial amount of habitat projected to have historically supported steelhead production. Increased water temperatures during the summer rearing period, increased fine sediment levels, and loss of natural stream structure limit survival and capacity for summer rearing and overwintering in these reaches.

The plans summarize results of habitat assessments that document the distribution and relative magnitude of habitat degradation throughout the drainages. The projections of potential responses to the proposed habitat restoration actions were developed based upon considerations for the results of the habitat assessments in each population and past experiences with restoration efforts. Restoring juvenile rearing conditions in tributary mainstem rearing areas included as priorities in each population will increase the range of historically important life history patterns, increasing the resilience of the populations to fluctuations in environmental conditions. Action strategies are aimed at reducing temperatures and sedimentation by restoring riparian cover, natural bank conditions and flow regimes in targeted reaches.

An important element of the restoration strategy for each population in this MPG is to increase survivals during the smolt outmigration phase through improvements to the spring flow and temperature regimes in the tributary mainstems and the Columbia River. Actions proposed in the plans are designed to build upon the flow and passage improvements that have been gained in recent years. Hatchery programs designed to boost natural recovery efforts and to provide fish for harvest operate within each of the populations. The recovery plan includes strategies designed to limit long-term risks to natural production by controlling the distribution and level of hatchery contributions within each population.

Table 7-3 Recovery Strategies and Actions for the Umatilla/Walla Walla MPG.

UMATILLA/WALLA WALLA MPG				
Strategies	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
Tributary Habitat				
Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	All populations in MPG	• Protect highest quality habitats through acquisition and conservation. • Adopt and manage Cooperative Agreements. • Conserve rare and unique functioning habitats. • Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	All Parameters	Degradation of tributary habitat-forming processes and functions (loss of channel structure, floodplain connectivity, riparian vegetation and LWD recruitment)
Restore passage and connectivity to habitats blocked or impaired by artificial barriers.	Umatilla River, Walla Walla River, Touchet River	• Remove or replace culverts and/or other passage barriers. • Construct ladders over existing dams. • Provide adequate screening at 100% of irrigation diversions. • Replace screens that do not meet criteria.	Abundance, Productivity, Spatial Structure	Loss of historical habitat because of blocked or impaired fish passage (dams, culverts, unscreened diversions)
Restore floodplain connectivity and function.	Umatilla River, Walla Walla River, Touchet River	• Reconnect side channels and off-channel habitats to stream channels. • Restore wet meadows. • Reconnect floodplain to channel.	Abundance, Productivity, Spatial Structure	Degraded floodplain connectivity and function (loss of off-channel habitat, side channels and connected hyporheic zone)
Restore channel structure and complexity.	Umatilla River, Walla Walla River, Touchet River	• Place stable wood and other large organic debris in streambeds. • Stabilize stream banks. • Restore natural channel form.	Abundance, Productivity	Degraded channel structure and complexity (loss of spawning and rearing habitat, LWD, pools)
Restore riparian condition and LWD recruitment.	Umatilla River, Walla Walla River, Touchet River	• Restore natural riparian vegetative communities. • Develop grazing strategies that promote riparian recovery. • Install/maintain fencing.	Abundance, Productivity	Degraded riparian condition (native riparian vegetative communities, LWD recruitment)
Restore altered hydrograph to provide sufficient flow during critical periods.	Umatilla River, Walla Walla River, Touchet River	• Restore natural functions and processes through actions identified in strategies above. • Implement Umatilla Basin Project Phases I-III. • Implement water conservation measures. • Improve irrigation conveyance and efficiency. • Investigate feasibility of water storage and exchange (WW).	Abundance, Productivity	Altered hydrology (low summer flow, scouring peak flows due to degraded watershed condition and/or streamflow alterations and withdrawals for irrigation and other uses.)

UMATILLA/WALLA WALLA MPG				
Strategies	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
		• Employ BMPs to forest, agriculture and grazing practices and to road management.		
Improve degraded water quality.	Umatilla River	• Reduce chemical pollution inputs. • Reduce discharge from mining and dredging areas. • Restore natural functions and processes through actions identified in strategies above. • Employ BMPs to forest, agriculture and grazing practices and to road management.	Abundance, Productivity	Degraded water quality (abnormal temperatures or fine sediment, nutrients from runoff, pesticides and other chemicals and/or because of water withdrawals that reduce natural stream flows.)
Harvest				
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	Umatilla River, Walla Walla River, Touchet River	• Maintain current management regulations for low impact fisheries and adjust tributary harvest regulations in areas where harvest significantly impacts steelhead viability.	Abundance, Productivity	Not a primary limiting factor
Hatchery				
Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish.	Umatilla River, Walla Walla River	NOTE: The following measures are recommended in one or more management unit plan but have not been agreed upon by all co-managers. • Implement representative coded-wire-tagging (CWT) program so all hatchery steelhead stocks have adequate CWT groups released annually. • Mark all hatchery steelhead releases in Columbia River Basin with, at a minimum, an adipose fin-clip. • Recommend development of alternative broodstocks to reduce stray rates for programs that contribute significantly to stray problem. • Reduce proportion of Snake River hatchery smolts that are transported from lower Granite and Little Goose dams.	Productivity, Diversity	Straying of out-of-DPS hatchery fish into natural spawning areas.
Reduce abundance and proportion of out-of-basin hatchery strays spawning naturally.	Umatilla River	• Uniquely mark Umatilla Hatchery steelhead and remove out-of-basin hatchery strays at Three Mile Falls Dam.	Productivity, Diversity	Out-of-basin hatchery strays in tributary natural spawning grounds.
Reduce abundance and proportion of out-of-basin hatchery strays spawning naturally.	Walla Walla River	• (These actions are currently non-consensus recommendations.)	Productivity, Diversity	Genetic risks from out-of-basin hatchery strays spawning naturally

UMATILLA/WALLA WALLA MPG				
Strategies	**Populations Affected and Addressed**	**Key Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
		• Eliminate adult hatchery strays above Nursery Bridge Dam by resuming trapping operations and removing hatchery fish. • Alter release strategy of Lyons Ferry hatchery smolts released into lower Walla Walla River from direct stream to acclimated releases. Implement trap and removal near acclimation site. • Develop local broodstock to replace Lyons Ferry stock for use in harvest augmentation program and to initiate a natural production supplementation program.		
Reduce abundance and proportion of out-of-basin hatchery strays spawning naturally.	Touchet River	• Continue development of Endemic Touchet River summer steelhead program to replace current releases of Lyons Ferry hatchery summer steelhead smolts. • Improve adult trap at the Dayton Pons diversion dam to improve management of returning adult hatchery summer steelhead. • Install weir on Copei Creek to monitor escapement of summer steelhead and remove hatchery strays.	Diversity	Genetic risks from out-of-basin hatchery strays spawning naturally
Re-establish natural production in historically utilized habitats.	Umatilla River	• Re-establish natural production in Little Butter and Butter creek drainages by outplanting adults and/or juveniles into tributaries after habitat conditions are restored.	Abundance, Productivity, Spatial Structure, Diversity	Loss of natural production in Butter Creek system.
Reduce genetic influence of hatchery fish in hatchery broodstock.	Umatilla River	• Eliminate use of hatchery-produced adults in broodstock.	Diversity	Potential divergence in genetic and phenotypic traits between hatchery and natural-origin steelhead.
Reduce interactions between residual hatchery steelhead and natural steelhead.	Umatilla River	• Conduct volitional releases of steelhead smolts and remove fish that do not migrate.	Abundance, Productivity, Diversity	Risk of hatchery fish competing with and preying on natural steelhead juveniles
Reduce potential negative ecological interactions between coho salmon and natural steelhead.	Umatilla River	• Reduce number of hatchery coho released in Umatilla River and relocate releases downstream to areas not currently important for steelhead production.		Potential for coho smolts to compete with juvenile steelhead for prey resources and space.

7.2.4 Yakima River MPG

Population	ICTRT Risk Status
Upper Yakima River	High Risk
Naches River	High Risk
Satus Creek	Moderate Risk
Toppenish Creek	Moderate Risk

The Yakima MPG is currently rated at High Risk. The two largest populations in the drainage (Naches and Upper Yakima) are rated at High Risk; the Satus Creek and Toppenish Creek populations are rated as Maintained.

Recovery Scenario: For the Yakima River MPG to achieve viable status, two populations should be rated as Viable, including at least one of the two classified as Large - the Naches River and the Upper Yakima River. The remaining two populations should, at a minimum, meet the ICTRT's Maintained criteria.

Gap: The median survival gap (assuming recent ocean and base hydrosystem conditions) for the Yakima MPG is 0.77 (needs 77 percent improvement in average survival over the life cycle), ranging from 0.22 (Satus—tributary only) to 1.15 (Upper Yakima). This is the highest median survival gap of the four MPGs that make up the Middle Columbia River DPS.

Key actions proposed (more detail in Table 7-3):

- Protect and enhance habitat in key tributary watersheds in the Yakima Basin.
- Restore passage to blocked areas in the Naches and Upper Yakima population areas.
- Alter irrigation delivery and storage operations in the Yakima Basin to improve flow conditions for Middle Columbia steelhead and use managed high flows to maintain floodplain habitat.
- Improve channel and floodplain function and reduce predation through the mainstem Yakima and Naches Rivers.
- Improve survival in the mainstem Columbia and its estuary through actions detailed in NMFS Estuary Module (NMFS 2007) and FCRPS Biological Opinion (NMFS 2008a).

Summary of Recovery Strategy:

Tributary and mainstem habitats for steelhead in the Yakima basin have been substantially altered from historical conditions. High quality rearing habitat has been substantially reduced or rendered inaccessible. Especially in the Naches and Upper Yakima mainstem reaches, degraded conditions such as flow reductions, increased temperatures, and altered stream structure have reduced survival and the expression of life history diversity.

Recovery actions proposed to benefit Yakima River steelhead populations are aimed at improving conditions across the freshwater habitats the fish use in all life stages – from incubation and rearing to juvenile and adult migration – especially in the Yakima River mainstem. This has the highest potential to quickly make a difference by increasing

productivity in the areas where fish now spawn and restoring the pattern of extended rearing in the mainstem. It is also important to restore flow and temperature conditions conducive to steelhead rearing in mainstem reaches of the Naches River and the Upper Yakima, which are believed to have supported substantial production historically. Restoring anadromous access into tributaries with large amounts of relatively high quality habitat by targeting flow improvements and barrier removals is also a high priority, especially for the two large populations in the upper Yakima basin.

The Yakima River enters the Columbia upstream of four major hydroelectric dams. Actions to improve passage and migration survival in the mainstem Columbia River and the estuary will also contribute to achieving objectives for the Yakima populations. Since Yakima-origin steelhead are harvested in mainstem Columbia River fisheries primarily directed on fall Chinook, harvest management is another important component of the recovery strategy for these and all Middle Columbia steelhead populations.

Table 7-4 Recovery Strategies and Actions for the Yakima Basin MPG.

YAKIMA RIVER MPG				
Highest Priority Strategies	**Populations Affected and Addressed**	**Key Types of Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
Tributary Habitat				
Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	All populations in MPG: Upper Yakima Naches Toppenish Satus	• Protect highest quality habitats through long-term protection and conservation. • Adopt and manage Cooperative Agreements. • Conserve rare and unique functioning habitats. • Consistently apply BMPs and existing laws to protect and conserve natural ecological processes.	All Parameters	Degradation of tributary habitat-forming processes and functions (loss of channel structure, floodplain connectivity, riparian vegetation and LWD recruitment)
Restore passage and connectivity to habitats blocked or impaired by artificial barriers.	All Populations	• Provide passage at selected Yakima and Naches River Storage Dams as feasible. • Remove or replace barriers blocking or impairing passage including dams, dikes, road culverts and irrigation structures. • Provide screening at 100% of irrigation diversions. • Replace screens that do not meet criteria.	Abundance, Productivity, Spatial Structure	Loss of historical habitat because of blocked or impaired fish passage (dams, culverts, seasonal push-up dams, unscreened diversions) Reduced survival due to delay and mortality due to entrainment in water diversions
Improve conditions for outmigrating smolts at diversion structures.	Upper Yakima Lower Yakima migratory area (affects all populations)	• Improve smolt passage at Roza Dam. • Reduce mortality at Chandler, Roza and other Diversion Dams.	Abundance, Productivity	Increased travel time and decreased survival for outmigrating smolts
Restore floodplain connectivity and function.	All Populations	• Reconnect side channels and off-channel habitats to stream channels. • Restore wet meadows. • Reconnect floodplain to channel. • Relocate or improve floodplain infrastruct. & roads.	Abundance, Productivity, Spatial Structure	Degraded floodplain connectivity and function (loss of off-channel habitat, side channels and connected hyporheic zone)
Restore channel structure and complexity.	All Populations	• Place stable wood and other large organic debris in stream banks. • Stabilize stream banks. • Restore natural channel form.	Abundance, Productivity	Degraded channel structure and complexity (loss of spawning and rearing habitat, LWD, pools)
Restore riparian condition and LWD recruitment.	All Populations	• Restore natural riparian vegetative communities. • Develop grazing strategies that promote riparian recovery.	Abundance, Productivity	Degraded riparian condition (native riparian vegetative communities, LWD recruitment)
Restore altered hydrograph to provide appropriate flows during critical periods.	All Populations	• Implement agricultural water conservation measures. • Improve irrigation conveyance and efficiency. Lease or acquire water rights and convert to instream. • Restore natural functions and processes through actions	Abundance, Productivity	Altered hydrology (low summer flow, scouring peak flows due to degraded watershed conditions, high summer delivery flows in mainstem Yakima Tieton and Naches rivers. Reduced winter and spring flows due to irrigation storage,

YAKIMA RIVER MPG				
Highest Priority Strategies	**Populations Affected and Addressed**	**Key Types of Actions**	**VSP Parameters Addressed**	**Limiting Factors Addressed**
		identified in strategies above. • Employ BMPs to forest, agriculture and grazing practices, and to road management. • Protect and/or rehabilitate springs. • Increase irrigation storage as feasible.		delivery and withdrawals)
Improve degraded water quality.	All Populations	• Reduce chemical pollution inputs. • Restore natural functions and processes through actions identified in strategies above. • Employ BMPs to forest, agriculture and grazing practices and to road management. • Upgrade or remove problem forest roads. • Conduct pathogen sampling and monitoring. • Construct water and sediment control basins.	Abundance, Productivity	Degraded water quality (abnormal temperatures or fine sediment, nutrients fro runoff, pesticides and other chemicals and/or because of water withdrawals that reduce natural stream flows.
Harvest				
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	All Populations	• Maintain current management regulations for low impact fisheries and adjust tributary harvest regulations in areas where harvest significantly impacts steelhead viability.	Abundance, Productivity	Not a primary limiting factor
Reduce illegal harvest on ESA-listed species.	All Populations	• Ensure adequate enforcement to prevent illegal harvest of steelhead	Abundance, Productivity	Not a primary limiting factor
Hatchery				
Restore natural production into historically utilized habitats, including blocked areas in tributaries and above storage dams where passage is provided.	Naches, Upper Yakima	• Develop plan for steelhead reintroductions into historical habitat when passage is restored. • Use small scale supplementation to re-establish natural production in MaSAs and some MiSAs	All Parameters	Risks related to steelhead reintroductions to historical habitat using inside-DPS hatchery fish
Promote repeat spawning of kelts.	All Populations	• Use kelt reconditioning program	All Parameters	Reduced survival of kelts due to passage conditions in the Columbia and lower Yakima

7.3 Setting Priorities

Priorities for recovery actions should be guided by DPS-, MPG-, and population-level recovery criteria and best available scientific information concerning DPS status, the role of the independent populations in meeting DPS and MPG viability, limiting factors and threats, and likelihood of effectiveness of actions. Protection of existing habitat is essential. Issues of funding and local, state, or national support for implementation will also inevitably come into play.

The management unit plans all address these issues in their implementation sections. The Oregon Steelhead Recovery Plan offers detailed considerations for prioritization that are also adopted by the Washington Gorge Plans. The Southeast Washington Plan describes "strategic guidelines" for prioritization. The Yakima Steelhead Plan notes that the process of working out an implementation schedule with stakeholder participation will ultimately set the priorities.

See Chapter 11, Implementation, for discussion of the organization of ongoing technical review and support from DPS and management unit science and technical committees. Coordination and communication in the Mid-C Forum and other venues will be necessary for actions in the Columbia mainstem, estuary, and/or ocean.

7.3.1 Oregon Steelhead Recovery Plan

The Oregon Steelhead Recovery Plan offers an approach to steelhead recovery that attempts to integrate both the biological needs of the fish and the economic, political, social, and cultural context in which strategies must be implemented and actions chosen. The plan provides an overview of the links between threats and limiting factors, management strategies, and types of actions (Table 7-5). This is followed by detailed tables for each of the 10 Oregon steelhead populations, identifying specific proposed actions, locations, limiting factors and threats addressed, VSP parameters and life stages affected. The tables also include assessments of existing programs relevant to the proposed actions. The Oregon Steelhead Recovery Plan is included as Appendix A of this Plan.

Table 7-5. Integrated approach to address threats and factors limiting recovery of Oregon's Middle Columbia River steelhead populations.

Threats and Limiting Factors	Management Strategies	Types of Actions
All degraded habitat limiting factors	Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	Protect highest quality habitats through acquisition and conservation. Adopt and manage Cooperative Agreements. Conserve rare and unique functioning habitats. Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.
Degraded Habitat - Impaired fish passage	Restore passage and connectivity to habitats blocked or impaired by artificial barriers, and maintain unimpaired passage and connectivity	Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures. Provide screening at 100% of irrigation diversions. Replace screens that do not meet criteria.
Degraded habitat - floodplain connectivity and function	Restore floodplain connectivity and function, and maintain unimpaired floodplain connectivity and function	Reconnect side channels and off-channel habitats to stream channels. Restore wet meadows. Reconnect floodplain to channel.
Degraded habitat - channel structure and complexity	Restore channel structure and complexity, and maintain unimpaired structure and complexity	Place stable wood and other large organic debris in streambeds. Stabilize stream banks. Restore natural channel form.
Degraded habitat - riparian area and LWD recruitment	Restore riparian condition and LWD recruitment, and maintain unimpaired conditions	Restore natural riparian vegetative communities. Develop grazing strategies that promote riparian recovery.
Degraded habitat - altered hydrology	Restore altered hydrograph to provide sufficient flow during critical periods	Implement agricultural water conservation measures. Improve irrigation conveyance and efficiency. Lease or acquire water rights and convert to instream.
Degraded habitat - water quality	Improve degraded water quality and maintain unimpaired water quality	Reduce chemical pollution inputs. Apply BMPs to animal feeding operations. Restore natural functions and processes through actions identified in strategies 1,3,4,5,8
Degraded habitat - altered sediment routing	Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes	Achieve 95% conversion to no till farming. Upgrade or remove problem forest roads. Restore native upland plant communities. Employ BMPs for forest practices, livestock grazing, road management and agricultural practices.
Degraded habitat - estuarine and Nearshore Marine	Restore degraded estuarine and nearshore habitat, and maintain unimpaired conditions	Protect/restore riparian areas Remove pile dikes Protect remaining high quality off-channel habitat Breach or lower dikes and levees Identify and reduce sources of pollutants Monitor and restore contaminated sites
Mainstem Columbia River hydro system	Improve salmonid migration and habitats, and reduce predation on and competition between salmonids in the mainstem Columbia River.	Adjust the timing, magnitude, and frequency of flows Mitigate/reduce reservoir heating Continue adult fish passage operations Improve juvenile fish passage Continue and enhance spill for juvenile fish passage Modify fish transportation to improve juvenile survival

Threats and Limiting Factors	Management Strategies	Types of Actions
Hatchery related adverse effects	Reduce hatchery related genetic and ecological effects on natural populations of Middle Columbia steelhead	Increase marking of Col. Basin hatchery steelhead with coded-wire tags. Require mass marking of all hatchery steelhead releases with, at a minimum, an adipose fin-clip. Increase efforts to monitor incidence of hatchery fish on spawning grounds. Develop plan for steelhead reintroduction into historical habitat when passage is restored. Eliminate the use of hatchery produced adults in the broodstock Construct trapping facilities
Harvest-related adverse effects	Manage fisheries to reduce harvest-related adverse effects	Use selective recreational fisheries to reduce the number of out-of-basin hatchery strays. Call for a voluntary curtailment of fishing at higher water temperatures (above 21°C) as a measure to reduce hook-and-release mortality Expand the creel surveys to monitor fisheries effort and catch
Predation, competition, disease	Reduce predation, competition and disease	Reduce predation by pinnipeds Redistribute Caspian terns Redistribute cormorants

The Oregon Steelhead Recovery Plan's recommendation for setting priorities is a list of "considerations," based on key principles derived from conservation biology and ecosystem management.

The principles for sound salmon recovery efforts:

1) Set aside or protect the highest quality habitat.
2) Do not let habitat conditions degrade further.
3) Maintain or restore critical ecological processes.
4) Develop goals and objectives based on deep understanding of ecological properties of the system.
5) Evolutionary processes must be conserved or restored.
6) Management must be adaptive and minimally intrusive.

The considerations for prioritizing actions:

We consider actions that achieve the following to be highest priority:

- *Actions that provide long-term protection of habitat conditions and conservation of natural ecological processes that support the viability of priority extant populations and their primary life history strategies throughout their entire life cycle. A population is considered a priority if it is critical for MPG or DPS viability.*
- *Actions that protect or enhance viability of multiple steelhead populations.*

- *Actions that support conservation of unique and rare functioning habitats, habitat diversity, life histories and genetic attributes.*
- *Actions that target the key limiting factors and that contribute the most to closing the gap between current status and desired future status of priority populations.*
- *Actions that provide critical information needed for assessing success and making adaptive management decisions.*

We consider the following types of actions to be high priority but less than highest:

- *Actions that enhance the habitat conditions and restore natural ecological processes of priority extant populations and their primary life history strategies throughout the entire life cycle.*
- *Actions that enhance the viability of priority extant populations.*
- *Actions that are required to protect and enhance habitats for populations that are not critical for MPG or ESU viability but must be maintained.*

Other things being equal, actions that demonstrate the following have enhanced priority:

- *Actions where opportunity for success is high (rather than those of limited feasibility).*
- *Actions that likely produce a large (rather than small) improvement in viability attributes.*
- *Actions that support restoration of normative ecological processes rather than short-term substitutions for normative processes.*
- *Actions that are complementary to other land management, water quality, environmental management and recreational objectives as specified in fish management, conservation, recovery or other plans developed with and supported by regional and subbasin stakeholders (rather than those that are isolated, stand-alone efforts).*
- *Actions that have regional and local support and generate increased participation.*
- *Actions that demonstrate cost effectiveness relative to alternative means of achieving the same objectives.*
- *Actions that have high degree of certainty in effectiveness and outcome. Source: ODFW 2009.*

The Oregon Steelhead Recovery Plan also proposes the following measures to address hatchery related genetic and ecological effects on natural populations of Middle Columbia steelhead:

- Increase efforts to monitor incidence of hatchery fish on spawning grounds.
- Develop and implement plan for steelhead reintroduction into historical habitat when passage is restored.
- Eliminate the use of hatchery-produced adults in the Umatilla River brood stock.
- Construct trapping facilities in the Deschutes River basin to remove stray hatchery fish.
- Use selective recreational fisheries to reduce the number of out-of-basin hatchery strays.

7.3.2 Washington Gorge Management Unit Plans

The Washington Gorge plans (White Salmon, Klickitat, and Rock Creek) identify recovery strategies in the same general order of importance as in the Oregon Steelhead Recovery Plan.

7.3.2.1 Klickitat Recovery Plan

The first priority for the Klickitat River steelhead population is to reduce the uncertainties and data gaps identified by the ICTRT. A targeted monitoring program will be designed to do the following:

- Determine abundance and productivity of natural steelhead spawners
- Determine the adverse effects of Skamania broodstock and out-of-subbasin strays on the Klickitat population, if any.
- Determine the effects of non-native coho and fall Chinook released from the hatcheries and naturalized in the river on naturally produced steelhead, if any.
- Continue study and further refine understanding of habitat limiting factors.

Further actions related to potential limiting factors:

- Minimize adverse impacts of large-scale hatchery releases of *U.S. v. Oregon* production stocks (coho and fall Chinook) on Klickitat steelhead. The satellite Wahkiacus Hatchery/Acclimation Facility at RM 17.0 is being developed so that existing U.S. v. Oregon production of fall Chinook and coho can be transferred from the Klickitat Hatchery 26 miles downstream to the Wahkiacus facility, transferring coho and fall Chinook production 26 miles downriver, to reduce and minimize the impacts of large-scale hatchery releases on wild spring Chinook and steelhead rearing between the two facilities.
- Determine and minimize impacts of hatchery trout releases in the subbasin.
- Improve steelhead passage at Lyle Falls Fishway.
- Assess steelhead natural recolonization of upper Klickitat watershed and the potential use of artificial propagation to accelerate recolonization.

To address habitat degradation in the Klickitat watershed, the plan proposes a strategy to protect and improve ecosystem functions and restore normative ecological processes. The components of the strategy are, first, to protect and maintain existing high quality and/or unimpaired habitats and ecosystem functions; and, second, to restore degraded habitat where appropriate, through passive and active measures.

Managing harvest for low impacts from both mainstem and tributary fisheries, and to reduce any adverse impacts that may be occurring, also is an important contribution to the population's viability.

7.3.2.2 Rock Creek Recovery Plan

The Rock Creek plan's recovery strategy aims to remove threats to the long-term survival of the population and improve population biological characteristics so it will, first, meet requirements for a Maintained population and support DPS recovery and, eventually, achieve viability and meet broader population goals. The recovery strategy focuses on (1) gaining information needed

to better assess population status and (2) removing key threats to population viability by improving freshwater habitat conditions.

7.3.2.3 White Salmon Recovery Plan

The White Salmon plan's recovery strategy contains two key parts: 1) a plan for reintroducing naturally produced steelhead into historical habitat after the removal of Condit Dam, and 2) improving and increasing freshwater habitat for steelhead production in the subbasin. The plan also recommends ensuring that harvest or hatchery actions do not impede efforts to improve steelhead viability. The White Salmon Technical Working Group is developing the reintroduction plan.

7.3.3 Southeast Washington Plan

The SRSRB developed its recovery strategies by means of a set of "strategic guidelines" weighed against proposed actions. However, for habitat protection and restoration actions, "imminent threats" to fish life in areas containing ESA-listed populations will receive the highest priority. Examples of imminent threats include adult fish passage barriers such as culverts or dams, unscreened or poorly screened irrigation diversions, stream crossings (fords or low water crossings) that are located in spawning areas and are used during the incubation period, dewatered reaches that strand or kill fish and act as passage barriers, and point sources of toxic pollutants. Removing imminent threats will likely result in the greatest increase in fish survival over the shortest time.

The overall strategic guidelines are as follows:

1. Emphasis will be placed on projects with long persistence time ("life span") and benefits distributed over the widest possible range of environmental attributes.
2. Recovery/restoration actions must include immediate measures in addition to long-term actions. Many actions that address the root causes of habitat degradation require a long time to achieve their goals. An example would be planting trees in riparian zones to: a) reduce instream temperatures, b) add large woody debris, and c) increase habitat complexity. Immediate actions that can "jump start" recovery can include such things as manual addition of large woody debris to stream channels, and creation of meanders in channelized streams.
3. The management strategy will involve "adaptive management"; that is, it will be a feedback system where changes in information or data detected through monitoring and evaluation will be used to adjust and modify plans and actions.
4. Identification of important areas and proposed actions is based substantially on information contained in the applicable subbasin plans.
5. Actions necessary to accomplish the recovery goals will be considered within the context of the four "Hs" (habitat, harvest, hatcheries, and hydroelectric).
6. Actions implemented within the region will be focused primarily on restoration and protection of habitat; actions pertinent to the other "Hs" will be addressed primarily through other planning processes, but the SRSRB may provide recommendations to these processes.
7. The EDT analysis tool, in combination with other analyses, empirical data and professional opinion, will be used to identify and prioritize habitat actions.

8. The final set of proposed actions will be subject to economic, social, and cultural constraints identified by the recovery region.
9. Priority actions are those that the SRSRB hopes to accomplish over the 15-year planning period of this plan.

In general, the habitat strategy is based on protection of high quality or productive habitat and restoration, preferably passive restoration, to revitalize degraded habitat. Specific habitat strategies were prioritized in the following way: Habitat characteristics or factors, such as substrate embeddedness, pools, or temperature, were correlated with general categories of appropriate action, such as improving riparian areas, improving channel and floodplain, or improving water quantity. The categories of action, called "approaches," were assigned priority in terms of effectiveness, technical feasibility, and cost/benefit. Objectives for restoration and protection were defined specifically; for example, the restoration objective for water temperature is to achieve a stream condition where the water temperature does not rise above 72° F for more than four days per month. The habitat factors were then arranged in order of importance for each major spawning area, and specific actions, funding sources, and potential costs were listed.

7.3.4 Yakima Steelhead Recovery Plan

Since the Yakima management unit encompasses all the populations of one MPG, the Yakima Steelhead Plan is structured to present a recovery strategy at the MPG-level. For this reason, the details of the Yakima recovery strategy are presented above in Section 7.2.4, Yakima River MPG.

8. SITE-SPECIFIC MANAGEMENT ACTIONS AND COST ESTIMATES

It is important to consider the unique characteristics and challenges of estimating time and cost for salmon and steelhead recovery, given the complex relationship of these fish to the environment and to human activities on land. NMFS estimates that recovery of the Middle Columbia steelhead DPS could take 25 to 50 years. The management unit plans (Appendices A through E) contain extensive lists of actions to recover the Middle Columbia steelhead DPS populations. These projects were developed using the most up-to-date assessment of Middle Columbia steelhead recovery needs. The management unit plans focus, for the most part, on actions within the next 5 to 15 years. There are many uncertainties involved in predicting the course of recovery and in estimating total costs. Such uncertainties include biological and ecosystem responses to recovery actions as well as long-term and future funding.

8.1 Site-Specific Management Actions

The proposed site-specific management actions at the population level are described in detail in Appendices A through E. It is possible that some of these actions will not be funded and that others will be proposed or added. It is important to note that the management unit plans are dynamic and subject to change through the adaptive management process. Implementation plans are often updated annually and generally cover a 3-to-10-year period. The reader is urged to refer to the management unit plans for up-to-date implementation schedules.

Proposed site-specific actions for the mainstem Columbia River and estuary are described in detail in the FCRPS Biological Opinion (NMFS 2008a) and the Hydro Module (NMFS 2008c), the Estuary Module (NMFS 2007), and *Artificial Propagation for Pacific Salmon*, Appendix C of the Supplemental Comprehensive Analysis of the FCRPS Biological Opinion (NMFS 2008a).

NMFS recognizes that to achieve recovery of ESA-listed salmon and steelhead in the Columbia River Basin, site-specific actions addressing all limiting factors and threats (habitat, hydropower, hatcheries, harvest, and ecological interactions including predation and competition) are necessary. In this recovery plan, the relative impacts of this full range of limiting factors and threats are identified and evaluated, although effective site-specific actions may be better developed or more feasible to implement in some sectors than in others. At this time, site-specific management actions are more fully developed for tributary habitat and mainstem hydropower than for hatcheries and harvest. Given that habitat protection and restoration actions generally take some time to yield ecosystem responses and improvements in fish populations, it is important to implement actions with more immediate benefits, as well as those whose benefits will accrue in the future.

Hatchery and harvest actions developed in other management processes will be important for recovery. For hatcheries, site-specific actions are being developed pursuant to the FCRPS consultation process, which requires Hatchery and Genetic Management Plans (HGMPs) for all facilities that affect listed salmon and steelhead in the Columbia Basin. Mainstem fisheries in the Columbia River will be implemented consistent with the recently completed U.S v. Oregon Agreement, which extends through 2017. Tributary fisheries are subject to Fishery Management and Evaluation Plans, many of which are now under review or scheduled for completion in the near future. Such plans have been and will be developed to be consistent with recovery plans, ESA

section 7(a)(2), and other ESA requirements. NMFS will continue to monitor these plans, using adaptive management, to assess implementation progress and consistency with recovery plans.

8.2 Cost Estimates

Cost estimates for recovery projects were provided by the management unit entities where available information was sufficient to do so. In some cases this was done in coordination with a NMFS economist at the Northwest Fisheries Science Center in Seattle using a regional recovery cost database, together with input and review from regional experts and representatives from the Middle Columbia Recovery Forum in 2007.

Cost estimates for proposed recovery projects were developed using the methods described in each management unit plan. No cost estimates are provided for (1) baseline actions (programs that are already in existence), which are listed as Not Applicable (N/A); or (2) actions that need costs to be developed, need unit costs, and/or need project scale estimates, which are listed as To Be Determined (TBD). Each management unit worked with regional experts to identify costs, scale, or unit costs for actions that required more information in the draft stage, and costs were updated to the extent possible for this final plan.

The total estimated cost of habitat recovery actions for the Middle Columbia steelhead DPS is approximately $235 million over the initial 5-year period, and approximately $996 million for all DPS-wide recovery actions for which sufficient information exists upon which to base an estimate (Table 8-1). This estimate includes expenditures by local, tribal, state, and Federal governments, private business, and individuals in implementing both capital projects and non-capital work. Administrative costs are embedded in the total management unit cost estimates in Table 8-1. However, they do not include costs associated with implementing actions within the lower Columbia River, estuary or Federal Columbia River Power System (FCRPS). Preliminary research, monitoring and evaluation costs have, in some cases, been estimated at the management unit level; however, these costs are not included at this time pending completion of research and monitoring plans and further development of each project.

Table 8-1 Summary of Cost Estimates for Habitat Projects for Middle Columbia Steelhead DPS.

Recovery Plan	First 5 Years ($M)	Total Cost ($M)
Oregon	$ 103.5	$ 512.8
Yakima Steelhead[36]	$ 91.9	$ 269.3
SE Washington[37]	$ 25.5	$ 76.4
Klickitat[38],[39]	$ 12.9	$ 129.4
Rock Creek[40]	$ 0.9	$ 1.8
White Salmon Steelhead	N/A	$ 6.5[41]
DPS Totals	**$ 234.7**	**$ 996.2**

Table 8-1 provides costs for implementing actions in the first five years for each management unit, together with total program costs in each management unit plan. The estimates in Table 8-1 do not include costs associated with baseline actions because these are actions categorized as part of ongoing, existing programs. The success of steelhead recovery is, however, dependent upon the continued support of ongoing baseline projects and programs.

There are several cautions that must be highlighted regarding these summary costs, because many of these estimates may be incomplete until actions are better defined. For example, the costs for potentially expensive projects such as land and water acquisition, water leasing, and research and monitoring have not yet been estimated for many populations. For other projects, unit cost estimates or determination of project scale may also still need to be calculated. Therefore, Table 8-1 presents preliminary summary costs for recovery that will likely increase when unit cost estimates, scale of projects, and costs for actions are determined and as projects are better defined.

These cost estimates do not include expenses associated with implementing actions within the lower Columbia River, estuary, or Federal Columbia River Power System (FCRPS), first, because of the basin-wide scope and applicability of these actions to all 13 Columbia Basin salmonid species listed

[36] The Yakima steelhead plan estimates costs for the first 6 years, and includes preliminary RME cost estimate of $300K/year. The 5-year estimate was extrapolated from the 6-year cost data.
[37] The SE Washington plan estimates annual steelhead implementation costs at about $5 million per year. The 5-year estimate was extrapolated by multiplying the annual amount by five.
[38] The Klickitat plan estimates costs for the first 10 years. The five-year estimate was extrapolated by dividing the 10-year amount in half.
[39] The Klickitat plan uses a 50-year period to estimate its total project costs.
[40] The Rock Creek plan estimates cost for the first 3 years and for years 4 to 10. The 5-year estimate was extrapolated by dividing the 10-year amount in half.
[41] Improvement of habitat in the White Salmon subbasin will likely improve conditions for all four listed salmonid species; however, there may be additional costs when recovery actions designed specifically for the three listed Lower Columbia salmon ESUs that spawn in the subbasin are figured in.

as threatened or endangered, and second, because they are considered "baseline actions" that are required through other processes such as section 7 consultations, FERC licensing agreements, and Habitat Conservation Plans. Cost estimates for estuary actions are included in a module that is incorporated into the Plan by reference, and is available on the NMFS website: www.nwr.noaa.gov/Salmon Recovery Planning/ESA Recovery Plans/Other Documents.cfm. The estuary recovery costs could be further refined following public comment on the module and on the ESA recovery plan for the three listed lower Columbia River ESUs and one listed lower Columbia River steelhead DPS in 2009. Costs for hatchery actions required through other processes such as consultations, permits, and 4(d) Rule implementation are not part of recovery costs reported here because the programs are already in existence or are undergoing required modifications. There are few estimated costs for recovery actions associated with harvest to report at this time. This is because no actions are currently proposed that go beyond those already being implemented through *U.S. v. Oregon* and other harvest management forums. In the event that additional harvest actions are implemented through these forums, those costs will be added during the implementation phase of this recovery plan. All cost estimates will be refined and updated over time.

Cost estimates from the draft cost chapters in the individual management plans were developed as consistently as possible, in that they all applied guidance provided by NMFS staff. However, the approaches vary to some degree given the local and independent nature of the planning groups. Costs developed in the management unit plans were estimated using several basic assumptions (i.e., neither baseline costs nor out-of-basin costs were included in the estimates) and used similar cost calculation methodologies. There are, however, differences in the timeframes for cost estimates.

8.2.1 Oregon Middle Columbia Steelhead Recovery Plan

Oregon's Middle Columbia Steelhead Recovery Plan presents extensive cost information for proposed recovery actions by strategies and populations in its Section 11 (Recovery Cost Summary Table) and two cost tables in Appendix I. Cost estimates for proposed recovery projects were developed using the unit cost method described in Section 11. Table I-1 (All Actions by Population, Strategy and Category) in Appendix I summarizes estimated total costs that can currently be identified for recovery actions in each Oregon population and strategy. These do not include certain high cost actions such as land and water acquisition or water leases. ODFW worked with regional experts to identify costs, scale or unit costs for actions that need more information during the public comment period. The Oregon Steelhead Recovery Plan's Appendix I, Table I-1 was updated with this new information for the final recovery plan. The total expected 5-year expenditure for all populations is $103,537,000. The overall total cost estimate for all proposed actions, where costs are available, for all populations is $512,843,328.

8.2.2 Washington Gorge Management Unit Plan

Costs are provided for the three smaller subbasin plans that make up the Washington Gorge management unit. Costs for steelhead habitat recovery for the White Salmon subbasin are included here; however, the White Salmon plan will be finalized as part of the Lower Columbia River ESA Recovery Plan because more than one species of listed salmonid spawns in the White Salmon subbasin.

8.2.2.1 Klickitat Recovery Plan

Costs for habitat recovery actions are estimated at approximately $26 million for years 1-10, approximately $104 million for years 11-50, and $130 million over a 50-year period. The funds to cover improvements at Lyle Falls and Castile Falls total $5.9 million (Klickitat Plan, Appendix B to this plan). Ongoing and expanded research monitoring and evaluation activities are estimated to cost roughly $4,484,402 total for years 1 to 3 and $15,142,783 total for years 4 through 10.

8.2.2.2 Rock Creek Recovery Plan

The plan estimates funding needs for habitat projects for the first 3 years at approximately $600,000. Total costs for recovery, expected to occur over a 10-year period, are approximately $1.8 million. Other costs will be developed as actions are proposed and implemented. The estimated cost for filling data gaps is roughly $3,350,000 over 10 years ($2,095,000 total for years 1 to 3 and $1,255,000 total for years 4 through 10).

8.2.2.3 White Salmon Steelhead Recovery Plan

The plan estimates costs for implementing the proposed habitat actions for the White Salmon drainage, based on the costs of specific reach actions identified in the plan. Habitat action costs for recovery over a 10-year time period are estimated to be $6.5 million ($2.17 million for years 1-3 and $4.33 million for years 4-10).

8.2.3 Southeast Washington Plan

The Southeast Washington Plan contains a 5-year implementation plan (2006-2011) with actions that can be carried out in the near future to reduce threats to listed fish. The plan's cost estimates are based on unit cost estimates for each type of project envisioned for seven major spawning areas (MaSA) in which listed fish reside. Of these, four MaSAs are home to Mid Columbia steelhead. For steelhead in these MaSAs, the plan estimates implementation cost as approximately $5 million per year and approximately $76 million for total costs to recovery, exclusive of monitoring and evaluation.

8.2.4 Yakima Steelhead Recovery Plan

The Yakima Steelhead Plan (Appendix E) identifies preliminary cost estimates for each action in accordance with NMFS' guidelines for developing cost estimates. The Plan categorizes each project's implementation as occurring over time spans of 0-3 years, 4-6 years, 6-10 years, or > 10 years. The estimate for projects expected to be completed within the first 6 years is approximately $110 million. The estimated total cost of recovery, for projects where sufficient information upon which to base an estimate exists, is approximately $211million.

8.3 Time Estimate

NMFS estimates that recovery of the Middle Columbia steelhead DPS could take 25 to 50 years. While the management unit plans contain extensive lists of actions to recover the Middle Columbia steelhead DPS populations, there are many uncertainties involved in predicting the course of recovery and in estimating total costs. Such uncertainties include biological and ecosystem responses to recovery actions as well as long-term and future funding. While continued programmatic actions in the management of habitat, hatcheries, hydro, and harvest will warrant additional expenditures beyond the first 10 years, NMFS believes it is impracticable to estimate all projected actions and

costs over 50 years, given the large number of economic, biological, and social variables involved. NMFS believes it is appropriate to focus on the first 5 years of implementation, with the proviso that before the end of the first implementation period, specific actions and costs will be estimated for subsequent years, to achieve long-term goals and to proceed until a determination is made that listing is no longer necessary.

9. POTENTIAL EFFECTS OF PROPOSED RECOVERY ACTIONS

This chapter presents an analysis of the potential effects of proposed recovery actions on the abundance and productivity of Middle Columbia River steelhead. Estimated levels of effectiveness for the proposed actions are generated and used as inputs into quantitative models to project the potential impacts of those changes on populations. In most cases, results are expressed as changes in steelhead abundance and productivity compared to the "baseline" abundance and productivity that the ICTRT calculated for the period 1980-2001. These quantitative analyses provide an opportunity to evaluate the efficacy of proposed recovery strategies in light of current knowledge regarding population functioning, including relationships with habitat conditions. Equally important, the quantitative models used in the assessment provide a framework for productively targeting evaluation efforts as well as for revisiting key assumptions in the future as more information becomes available (e.g., from monitoring responses to initial implementation or from evaluation efforts targeting key uncertainties).

The analyses were performed sequentially, first by projecting effects for tributary habitat actions alone, then sequentially adding in hatchery, hydro, predation, estuary, and harvest actions. The results at each step provide a means for comparing estimated relative benefits of the proposed suites of actions, and, finally, the potential benefit of all the proposed actions to the Middle Columbia steelhead DPS. Last, these results are compared to the gaps identified by the ICTRT (see Chapter 5 of this Plan).

Two models were used: Ecosystem Diagnosis and Treatment (EDT) and the All-H-Analyzer (AHA). The EDT model has commonly been used in regional planning efforts across the DPS to evaluate potential responses to tributary habitat restoration efforts. The EDT model uses derived relationships between habitat characteristics and fish survival to calculate changes in survival, abundance, and productivity that could result from changes in the habitat. Use of the EDT model requires a set of inputs that describe current habitat conditions and the expected changes in habitat conditions that would result from a proposed action scenario. This model could be used, for example, to calculate the improvement that would be expected from a 10 percent drop in water temperature during the period of egg incubation in a certain tributary reach. The AHA model encompasses prospective relationships between all the "H" factors: habitat, hatcheries, hydro, and harvest. Thus, the results of the EDT model become one set of information fed into the AHA model to produce an estimate of the benefits of all the proposed actions.

For the Oregon populations, modifications were made to the EDT and AHA models to improve their application for this analysis. These modifications or refinements are described in Chapter 10 of the Oregon Steelhead Recovery Plan (Appendix A), as follows:

"EDT and AHA address different life stages in the life cycle and thus the different limiting factors that affect salmonid population performance (Figure 10-1). We incorporated several refinements to the modeling procedures for each platform as they are usually employed in the region to improve application for our objectives. For EDT, we formulated an auxiliary tool for defining action effectiveness to better ensure that we considered the distinct elements of effectiveness consistently between actions and subbasins, and we incorporated an implementation timeframe element. For AHA, we disaggregated the life cycle into more segments than used in

the standard AHA in order to completely incorporate the effects of habitat conditions in the juvenile life stages following emigration from the subbasin through the adult life stages, until return to the subbasin. We also formulated a module for AHA to provide an efficient way of processing the large number of action combinations—both in tributaries and the mainstem Columbia—of interest to this analysis. In addition, we modified the default settings in AHA for genetic fitness to produce results that appear to be more consistent with how the populations of interest are currently performing" (ODFW 2008).

The models indicate, based on the suites of proposed actions in all the sectors, that all Middle Columbia River steelhead populations for which there are adequate data are expected to achieve less than 5 percent risk for abundance/productivity if the most intensive (major) restoration scenarios are implemented and the projected habitat changes are realized. Under minimum restoration scenarios, three populations (Deschutes Westside, Satus, and Upper Yakima) may not achieve less than 5 percent risk for abundance/productivity. However, even under poor ocean conditions and minimum restoration actions, the abundance and productivity of these three populations are expected to increase considerably over the baseline.

The results of the modeling analyses of the restoration scenarios are summarized by population in Section 9.2, by MPG in Section 9.3 and for the DPS in Section 9.4. Section 9.1 describes technical aspects of the analytical method.

It is important to note that the modeling results relative to recovery criteria are a function of the input information and key assumptions associated with the translation of actions into habitat changes, habitat and life-stage survival relationships, and population dynamics. Although the modeling provides valuable insight into the potential responses to recovery actions, the estimated potential responses are dependent on the assumptions and information put into the models.

9.1 Integration Approach

The analysis of action effectiveness for all populations except Rock Creek was performed using two modeling platforms: Ecosystem Diagnosis and Treatment (EDT) and the All-H-Analyzer (AHA). Linking the two models provided a way of projecting benefits measured at the end of the life cycle for a wide range of actions, regardless of what life stage an action affects.

For the Oregon Middle Columbia steelhead populations and for a description of the modeling approach, this chapter relies substantially on the analysis performed by ODFW biologists and detailed in Section 10 of the Oregon Steelhead Recovery Plan (ODFW 2008). The Oregon analyses considered tributary habitat changes projected for reach specific action strategies. The Yakima and SE Washington area population level model assessments incorporated results from more generic EDT tributary habitat restoration scenario analyses.

Estimates of the relative changes in population abundance and productivity associated with potential changes in tributary habitat conditions for the Touchet and the four Yakima populations were compiled in the regional recovery plans. A set of estimates for the Klickitat population was provided by Yakama Nation Fisheries biologists. All of these estimates for Washington area steelhead populations were based on EDT model runs generated for previous planning exercises (e.g., NWPPC 2004 Subbasin Plans).

Benefits associated with proposed actions for the Rock Creek steelhead population were estimated with the simple, multiplicative approach used in NMFS' 2008 FCRPS Biological Opinion (Comprehensive Analysis of Federal Columbia River Power System and Mainstem Effects of Upper Snake and Other Tributary Actions [CA]) and the Supplemental CA [SCA]). This approach estimated only density-independent survivals, unlike EDT and AHA, which modeled density dependent effects.

9.1.1 EDT Model

The EDT model was used to analyze the potential benefits of tributary habitat actions. In the Oregon Steelhead Recovery Plan, four scenarios were modeled for each Oregon Mid-C steelhead population, using EDT: (1) actions only in high priority areas at 25 years in the future; (2) actions only in high priority areas at 100 years in the future; (3) actions in all priority areas at 25 years in the future; and (4) actions in all priority areas at 100 years in the future. The expected change in habitat conditions assuming that the tributary protection and restoration actions are implemented following the general schedule described for each population was input into the EDT model for each scenario. The model results for a particular scenario represent the expected average performance of a population over a number of years given the specified habitat conditions. In addition, the Deschutes Westside population was modeled with and without passage at the Pelton-Round Butte Complex to estimate added benefits of passage and restoration of natural production in the blocked areas (see Oregon Steelhead Recovery Plan for more details).

Assessments of the potential response to tributary habitat changes resulting from implementation of the proposed actions for the Washington area populations were adapted from EDT analyses generated in developing the 2004/2005 NWPPC subbasin plans. Some modifications were made to reflect updates to the proposed tributary actions incorporated into the regional draft recovery plans. A single recovery action scenario was modeled for Washington populations, the model results represent the expected average performance of a population over a period of years given the projected changes in habitat conditions input into the EDT model corresponding to the proposed recovery strategy. For populations in Washington, no distinction was made between high priority actions and other actions; all actions were modeled, and future time horizons were only specified for the Walla Walla and Touchet populations (10-15 years future). Therefore, to complete the exercise for the Walla Walla population, which spawns in both states, the model combined Washington actions (10-15-year time horizon) with Oregon actions (all priority actions) using the 25-year time horizon.

Two different restoration scenarios were modeled for populations in the Yakima Basin. The first scenario, referred to as "minimum habitat restoration," used an updated version of the reference conditions from the Yakima Subbasin Plan, as described in the Yakima Steelhead Recovery Plan. The second scenario, referred to as "major habitat restoration," assumed that restoration actions will achieve about 50 percent of "properly functioning conditions" (a standardized set of criteria for watershed restoration [NMFS 1996]), across the basin. For both the Satus Creek and Toppenish River populations, the scenarios assumed that the basin consisted predominantly of anadromous life history types. For the Naches and Upper Yakima populations, the model was configured to partition habitat between resident and anadromous life history types and assume a steady-state abundance for resident fish. Performance of the Klickitat population was also

modeled under two different restoration scenarios. One included restoring conditions in areas already used by steelhead (i.e., it did not include recolonization of areas upstream from Castile Falls); the other included recolonization of the upper watershed (upstream from Castile Falls) and restoration of habitat throughout the basin. Both restoration scenarios assumed that major habitat limiting factors would be restored to 40 percent effectiveness.

For Oregon populations, the Oregon Steelhead Recovery Plan considered the influence of five factors for determining how effective an action may be in improving habitat conditions. The five factors were: (1) potential effectiveness – maximum effect of action type when fully implemented in targeted area; (2) intensity – scale of implementation within the targeted geographic area; (3) time lag – amount of potential effectiveness realized after 25 or 100 years; (4) schedule – delay in realizing potential effect due to implementation schedule; and (5) attribute – amount of reduced effectiveness associated with a specific attribute. The product of these scalars resulted in a "realized effectiveness" for each attribute (see Section 10.1.2 in the Oregon Steelhead Recovery Plan for more details).

9.1.2 AHA Model

The purpose of using the AHA model was to integrate the effects of various types of actions over the full life cycle of the fish. In the AHA model, the EDT analyses of tributary habitat actions were linked to prospective recovery actions involving hatchery fish and the mainstem Columbia River. This provided a way of projecting benefits measured at the end of the life cycle for a wide range of potential actions, regardless of what life stage an action affected. Section 10 in the Oregon Steelhead Recovery Plan describes in detail the AHA modeling approach.

For all populations except Rock Creek, AHA was used to model a set of scenarios representing baseline conditions (average conditions for migration years 1980-2001), current conditions (average conditions for migration years 2002-2006), and combinations of actions aimed at tributary habitat, mainstem Columbia River factors, and hatchery fish management. The model allowed the inclusion of potential effects of hatchery programs on the genetic fitness of the naturally produced populations. It also included several prospective actions to be implemented in the mainstem Columbia River, including: predator management – aimed at reducing predation rates caused by terns and northern pikeminnow; downstream juvenile passage improvements – measures to improve survival at each of the mainstem dams; Columbia estuary habitat improvements – measures to enhance habitat conditions within the Columbia estuary; and harvest – regulatory measures to reduce or hold harvest impacts in the mainstem Columbia River to current levels. The model incorporated survival improvement estimates for predation, hydrosystem, and estuary actions that were provided in the CA and SCA reports.

Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially. Using AHA, the effects of hatchery programs on genetic fitness of natural-origin fish were incorporated for each scenario. Actions intending to control the number of stray hatchery fish in subbasins were modeled as part of another set of scenarios. Finally, the effects of potential changes in marine survival were modeled. All of the scenarios were modeled using an average marine survival rate corresponding to the average during both the baseline and current periods. Then, two additional scenarios were modeled; one representing relatively good

ocean conditions (125 percent of the average condition) and the other representing relatively poor ocean conditions (75 percent of the average condition).

The output from AHA was expressed as Beverton-Holt population parameters, which represent the expectations of change for each population's abundance and productivity as a result of all the proposed actions. This change can be thought of as a percent change (e.g., 25 percent) or a ratio (e.g., 1.25). This needed to be "translated" into the same terms as the ICTRT's baseline abundance and productivity calculations for each population, which were derived empirically. Therefore, the ICTRT's baseline abundance and productivity values for each population were multiplied by the percent of change estimated by the AHA model. For example, if the AHA model indicated that abundance for a certain population will increase by 25 percent as a result of the proposed actions, then the ICTRT baseline abundance for that population was multiplied by 1.25 to get the projected estimate for abundance for that population under the recovery scenario. These calculations are described fully in Section 10.1 in the Oregon Steelhead Recovery Plan and shown in Figure 10-2 in the Oregon Steelhead Recovery Plan.

9.2 Effects of Recovery Actions

This section presents a summary of results of the benefits of proposed actions on Middle Columbia steelhead populations (see respective management unit recovery plans [Appendices A-E]for more detail). Changes in performance measures associated with each action scenario are presented for intrinsic productivity and spawner abundance. Except where noted otherwise, the results are comparable to population metrics for baseline performance, as derived empirically by the ICTRT, and to minimum productivity (at the threshold abundance level) and abundance viability thresholds at the 5 percent risk level in a 100-year time period. Performance measures are given for three periods: base period (1980-2001), base-current period (2002-2006), and the current-prospective period (2006-future). The latter varies depending on population. For those populations entirely within Oregon, the prospective period includes results at 25 and 100 years in the future. For Walla Walla and Touchet populations, results are projected ≤ 25 years in the future, while those in the Yakima and Klickitat have no defined future time horizon. A more detailed presentation of results for Oregon populations can be found in Sections 10.2 and 10.3 in the Oregon Steelhead Recovery Plan. Section 10.2 of the Oregon Steelhead Recovery Plan includes maps for each population showing the geographic areas that are currently in protected status, stream reaches where high priority actions are proposed, and restoration benefits from high priority actions for all reaches (ODFW 2009).

9.2.1 Cascades Eastern Slope Tributaries MPG

Deschutes River Westside Population

Abundance and productivity are projected to increase for all scenario combinations analyzed for Deschutes River Westside steelhead (Table 8.4; Oregon Steelhead Recovery Plan). The largest increases in population performance are associated with decreasing the number of stray hatchery fish and/or by providing passage at the Pelton-Round Butte Complex (including passage at Whychus Creek barriers). In the absence of the removal of strays or passage, benefits are much reduced. For those scenario combinations lacking removal of strays and passage, beneficial effects of tributary actions are greatest. However, predicted increases in abundance and productivity associated with habitat actions are less than 20 percent and between 35-55 percent, respectively.

Table 9-1 shows estimated abundance and productivity for the Deschutes River Westside population associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without passage at Pelton-Round Butte Dam Complex and with and without action to reduce the number of hatchery strays by 95 percent of those expected to enter the relevant area for the scenario. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25 percent represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario. Data are from Table 10-39 in the Oregon Steelhead Recovery Plan.

Table 9-1. Estimated Productivity and Abundance of Deschutes River Westside Steelhead with Proposed Actions.

Performance period	Scenario combination	Performance metric					
		Productivity			Abundance		
		No passage and no stray action	No passage with stray action	Passage with stray action	No passage and no stray action	No passage with stray action	Passage with stray action
Base		1.05			456		
Base-Current		1.17	1.84		514	557	
Current-Prospective (25 yrs future)	Habitat	1.59	2.44	2.39	578	610	880
	Hydro	1.67	2.57	2.52	610	641	925
	Predation	1.74	2.68	2.63	638	669	966
	Estuary	1.84	2.84	2.78	675	707	1,020
	Harvest	1.84	2.84	2.78	675	707	1,020
	Ocean ±25%	1.38-2.29	2.13-3.55	2.08-3.47	497-844	530-875	763-1,263
Current-Prospective (100 yrs future)	Habitat	1.82	2.78	2.74	630	660	931
	Hydro	1.92	2.92	2.88	665	694	978
	Predation	2.00	3.05	3.01	696	725	1,020
	Estuary	2.11	3.23	3.18	738	767	1,077
	Harvest	2.11	3.23	3.18	738	767	1,077
	Ocean ±25%	1.59-2.64	2.42-4.03	2.39-3.98	542-927	571-955	810-1,329

Deschutes River Eastside Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Deschutes River Eastside steelhead (Table 9.5; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with the greatest benefits accruing for the 100-year scenario. It is predicted that between 50-70 percent

of historical habitat potential for abundance will be achieved. The amount of habitat potential reflected in productivity, however, is somewhat less, being between 25-45 percent of potential. This means that the habitat actions will have a greater effect on habitat quantity than on habitat quality. Substantial benefits to both productivity and abundance are also expected to occur as a result of reducing the number of stray hatchery fish spawning with naturally produced fish.

Table 9-2 shows estimated population performance (productivity and abundance) of Deschutes River Eastside steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without action to reduce the number of hatchery strays by 95 percent of those expected to enter the relevant areas for the scenario. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25 percent represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario. Data are from Table 10-38 in the Oregon Steelhead Recovery Plan.

Table 9-2. Estimated Productivity and Abundance of Deschutes River Eastside Steelhead with Proposed Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		No stray action	With stray action	No stray action	With stray action
Base		1.89		1,599	
Base-Current		2.10	3.71	2,340	4,634
Current-Prospective (25 yrs future)	Habitat	4.26	6.80	6,973	8,323
	Hydro	4.47	7.15	7,471	8,818
	Predation	4.67	7.47	7,921	9,265
	Estuary	4.93	7.89	8,520	9,859
	Harvest	4.93	7.89	8,520	9,859
	Ocean ±25%	3.71-6.13	5.91-9.88	5,679-11,199	7,039-12,519
Current-Prospective (100 yrs future)	Habitat	5.97	9.20	8,643	9,619
	Hydro	6.26	9.67	9,174	10,151
	Predation	6.53	10.10	9,656	10,632
	Estuary	6.89	10.68	10,295	11,272
	Harvest	6.89	10.68	10,295	11,272
	Ocean ±25%	5.22-8.54	8.00-13.35	7,265-13,167	8,239-14,140

Klickitat River Population

Abundance and productivity are projected to increase for all scenario combinations analyzed for Klickitat River steelhead (Table 9-6; note that performance values in the table are direct output from EDT/AHA and have not been converted into ICTRT-equivalent performance values). The largest contribution to performance improvements results from the combination of tributary habitat actions throughout the basin and recolonization of the upper watershed (recolonization of the upper watershed is possible because of passage improvements at Castile Falls). In contrast, relatively small increases are attributable to mainstem actions.

Table 9-3 shows estimated population performance (productivity and abundance) of Klickitat River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly from EDT/AHA and were not converted to ICTRT-equivalent performance values (the ICTRT was unable to empirically estimate baseline performance measures for this population because of a lack of data). Results are shown with and without recolonization of the upper watershed. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-3. Estimated Productivity and Abundance of Klickitat River steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		Actions without recolonization of upper watershed	Actions with recolonization of upper watershed	Actions without recolonization of upper watershed	Actions with recolonization of upper watershed
Base		1.77		939	
Base-Current		1.92	1.92	1,118	1,118
Current-Prospective	Habitat	2.12	2.38	1,319	2,320
	Hydro	2.24	2.50	1,468	2,572
	Predation	2.29	2.56	1,538	2,692
	Estuary	2.36	2.62	1,630	2,850
	Harvest	2.36	2.62	1,630	2,850
	Ocean ±25%	2.01-2.64	2.27-2.90	1,181-2,026	2,088-3,539

Fifteenmile Creek Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Fifteenmile Creek steelhead (Table 9.7; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions. It is predicted that between 50-70 percent of historical habitat potential for both productivity and

abundance will be achieved. In contrast, relatively small increases are attributable to mainstem actions.

Table 9-4 shows estimated population performance (productivity and abundance) of Fifteenmile Creek steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario. Data are from Table 10-37 in the Oregon Steelhead Recovery Plan.

Table 9-4. Estimated Productivity and Abundance of Fifteenmile Creek Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		1.82	703
Base-Current		1.96	764
Current-Prospective (25 yrs future)	Habitat	3.02	1,342
	Hydro	3.02	1,345
	Predation	3.16	1,410
	Estuary	3.34	1,496
	Harvest	3.34	1,496
	Ocean ±25%	2.50-4.17	1,095-1,898
Current-Prospective (100 yrs future)	Habitat	3.79	1,502
	Hydro	3.80	1,506
	Predation	3.96	1,577
	Estuary	4.19	1,672
	Harvest	4.19	1,672
	Ocean ±25%	3.14-5.24	1,230-2,114

Rock Creek Population

Because no ETD/AHA modeling was conducted for Rock Creek steelhead, potential benefits in productivity were estimated with the multiplicative approach used in the FCRPS BiOp (CA and SCA reports). This approach did not estimate productivity or abundance values. Rather, it estimated changes in productivity associated with actions within each sector (habitat, hatchery, hydrosystem, predation, estuary, and harvest). Values for habitat should be considered a minimum estimate, given that the FCRPS BiOp assumed no habitat restoration actions in the subbasin.

Based on the survival changes presented in the FCRPS BiOp for each sector, Rock Creek steelhead productivity was projected to increase about 13 percent during the base-current period (Table 9-8). For the current-prospective period, productivity is projected to increase about 21 percent. Most of this increase is associated with actions in the hydrosystem and estuary.

Table 9-5 shows estimated proportional changes in average base-period productivity of Rock Creek steelhead expected from completed actions and current human activities that are likely to continue in the future (base-current) and proposed future tributary and out-of-subbasin actions (current-prospective). Estimates greater than 1.00 result in higher survival (e.g., 1.134 indicates a 13.4 percent increase in survival, compared to the base period average); 1.00 indicates no change; and estimates less than 1.00 result in lower survival (e.g., 0.997 indicates a 0.3 percent reduction in survival, compared to the base period average. Because no EDT/AHA modeling was completed for Rock Creek steelhead, estimated changes in productivity are from the FCRPS BiOp (SCA and CA reports).

Table 9-5. Estimated Proportional Changes in Average Base-Period Productivity of Rock Creek Steelhead.

Performance period	Scenario combination*	Change in Productivity
Base-Current	Habitat	1.000
	Hydro	1.090
	Predation	0.997
	Estuary	1.003
	Harvest	1.040
	Hatchery	1.000
	Total	1.134
Current-Prospective	Habitat	1.000
	Hydro	1.100
	Predation	1.044
	Estuary	1.057
	Harvest	1.000
	Hatchery	1.000
	Total	1.214

Tributary habitat estimates are from CA Chapter 10, Table 10-9; hydro estimates are from SCA Hydro Modeling Appendix B; predation estimates are from CA Appendix F, Attachment F-1 (for pikeminnow predation), CA Appendix F, Attachment F-2, Table 4, based on the "Prospective 2 S/Current 2 S" approach (for bird predation), and SCA Marine Mammal Appendix (for marine mammal predation); and estuary estimates are from CA Appendix D, Attachment D-1, Table 6. The analyses assumed no survival changes associated with harvest or hatchery programs. Total survival improvement multipliers are the product of the survival improvement multipliers in each previous row.

9.2.2 John Day River MPG

Lower John Day River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Lower John Day River steelhead (Table 9.9; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100-year scenario. It is predicted that habitat actions can achieve about 31-40 percent of historical habitat potential for both productivity and abundance. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-6 shows estimated population performance (productivity and abundance) of Lower John Day River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions

sequentially, each being added to the previous scenario. Data are from Table 10-40 in the Oregon Steelhead Recovery Plan.

Table 9-6. Estimated Productivity and Abundance of Lower John Day River steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		2.99	1,800
Base-Current		3.44	2,423
Current-Prospective (25 yrs future)	Habitat	4.99	5,751
	Hydro	5.43	6,537
	Predation	5.65	6,918
	Estuary	5.94	7,427
	Harvest	5.94	7,427
	Ocean ±25%	4.61-7.33	5,047-9,722
Current-Prospective (100 yrs future)	Habitat	7.31	8,627
	Hydro	7.94	9,628
	Predation	8.25	10,112
	Estuary	8.67	10,758
	Harvest	8.67	10,758
	Ocean ±25%	6.77-10.66	7,728-13,667

North Fork John Day River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for North Fork John Day River steelhead (Table 9.10; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100-year scenario. It is predicted that habitat actions can achieve about 45-55 percent of historical habitat potential for both productivity and abundance. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-7 shows estimated population performance (productivity and abundance) of North Fork John Day River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25 percent represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in

actions sequentially, each being added to the previous scenario. Data are from Table 10-41 in the Oregon Steelhead Recovery Plan.

Table 9-7. Estimated Population Performance (Productivity and Abundance) of North Fork John Day River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		2.41	1,740
Base-Current		2.77	2,101
Current-Prospective (25 yrs future)	Habitat	3.44	2,762
	Hydro	3.77	3,090
	Predation	3.94	3,248
	Estuary	4.16	3,458
	Harvest	4.16	3,458
	Ocean ±25%	3.14-5.18	2,465-4,404
Current-Prospective (100 yrs future)	Habitat	4.03	3,209
	Hydro	4.42	3,572
	Predation	4.61	3,747
	Estuary	4.87	3,980
	Harvest	4.87	3,980
	Ocean ±25%	3.69-6.06	2,880-5,028

Middle Fork John Day River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Middle Fork John Day River steelhead (Table 9.11; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100-year scenario. It is predicted that habitat actions can achieve about 40-55 percent of historical habitat potential for both productivity and abundance. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-8 shows estimated population performance (productivity and abundance) of Middle Fork John Day River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in

actions sequentially, each being added to the previous scenario. Data are from Table 10-42 in the Oregon Steelhead Recovery Plan.

Table 9-8. Estimated Population Performance (Productivity and Abundance) of Middle Fork John Day River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		2.45	756
Base-Current		2.82	921
Current-Prospective (25 yrs future)	Habitat	4.24	1,385
	Hydro	4.64	1,545
	Predation	4.84	1,622
	Estuary	5.11	1,724
	Harvest	5.11	1,724
	Ocean ±25%	3.88-6.35	1,240-2,186
Current-Prospective (100 yrs future)	Habitat	5.46	1,694
	Hydro	5.97	1,878
	Predation	6.23	1,966
	Estuary	6.57	2,084
	Harvest	6.57	2,084
	Ocean ±25%	5.00-8.15	1,528-2,616

South Fork John Day River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for South Fork John Day River steelhead (Table 9.12; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100-year scenario. It is predicted that habitat actions can achieve about 40-55 percent of historical habitat potential for both productivity and abundance. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-9 shows estimated population performance (productivity and abundance) of South Fork John Day River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in

actions sequentially, each being added to the previous scenario. Data are from Table 10-43 in the Oregon Steelhead Recovery Plan.

Table 9-9. Estimated Population Performance (Productivity and Abundance) of South Fork John Day River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		2.06	259
Base-Current		2.37	315
Current-Prospective (25 yrs future)	Habitat	3.03	414
	Hydro	3.32	464
	Predation	3.46	488
	Estuary	3.66	520
	Harvest	3.66	520
	Ocean ±25%	2.76-4.55	369-665
Current-Prospective (100 yrs future)	Habitat	3.72	491
	Hydro	4.07	546
	Predation	4.25	573
	Estuary	4.48	609
	Harvest	4.48	609
	Ocean ±25%	3.40-5.57	440-769

Upper John Day River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Upper John Day River steelhead (Table 9.13; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100-year scenario. It is predicted that habitat actions can achieve about 35-55 percent of historical habitat potential for both productivity and abundance. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-10 shows estimated population performance (productivity and abundance) of Upper John Day River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario. Data are from Table 10-44 in the Oregon Steelhead Recovery Plan.

Table 9-10. Estimated Population Performance (Productivity and Abundance) of Upper John Day River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		2.14	524
Base-Current		2.46	650
Current-Prospective (25 yrs future)	Habitat	4.14	1,262
	Hydro	4.52	1,409
	Predation	4.71	1,480
	Estuary	4.97	1,575
	Harvest	4.97	1,575
	Ocean ±25%	3.79-6.16	1,129-2,004
Current-Prospective (100 yrs future)	Habitat	5.35	1,566
	Hydro	5.85	1,738
	Predation	6.09	1,821
	Estuary	6.42	1,931
	Harvest	6.42	1,931
	Ocean ±25%	4.91-7.95	1,411-2,431

9.2.3 Umatilla/Walla Walla MPG

Umatilla River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Umatilla River steelhead (Table 9.14; Oregon Steelhead Recovery Plan). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100-year scenario. It is predicted that habitat actions can achieve about 45-70 percent of historical habitat potential for both productivity and abundance. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-11 shows estimated population performance (productivity and abundance) of Umatilla River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario. Data are from Table 10-45 in the Oregon Steelhead Recovery Plan.

Table 9-11 Estimated Population Performance (Productivity and Abundance) of Umatilla River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		1.50	1,472
Base-Current		1.73	1,820
Current-Prospective (25 yrs future)	Habitat	3.18	3,685
	Hydro	3.50	4,092
	Predation	3.65	4,287
	Estuary	3.86	4,545
	Harvest	3.86	4,545
	Ocean ±25%	2.90-4.82	3,313-5,693
Current-Prospective (100 yrs future)	Habitat	4.03	4,355
	Hydro	4.42	4,808
	Predation	4.62	5,026
	Estuary	4.88	5,314
	Harvest	4.88	5,314
	Ocean ±25%	3.67-6.09	3,940-6,592

Walla Walla River Population

Abundance and productivity are projected to increase markedly for all scenario combinations analyzed for Walla Walla River steelhead (Table 9-12a and 9-12b). The largest contribution to performance improvements results from tributary habitat actions. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-12a shows estimated population performance (productivity and abundance) of Walla Walla River steelhead associated with combinations of all priority tributary and out-of-subbasin actions, including combined benefits of actions proposed in the Oregon portion of the Walla Walla basin with those proposed in the Washington portion of the basin. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-12a. Estimated Productivity and Abundance of Walla Walla River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions, Including both Oregon and Washington.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		1.34	650
Base-Current		1.60	864
Current-Prospective (25 yrs future)	Habitat	2.78	2,214
	Hydro	3.12	2,515
	Predation	3.25	2,634
	Estuary	3.44	2,790
	Harvest	3.44	2,790
	Ocean ±25%	2.58-4.30	2,033-3,465

Table 9-12b. Estimated population performance (productivity and abundance) of Walla Walla River steelhead associated with combinations of all priority tributary actions only within the Oregon portion of the Walla Walla basin and out-of-subbasin actions (this analysis does not include habitat actions proposed within the Washington portion of the Walla Walla basin). Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario. Data are from Table 10-46 in the Oregon Steelhead Recovery Plan.

Table 9-12b. Estimated Productivity and Abundance of Walla Walla River Steelhead associated with Combinations of all Priority Tributary Actions within Oregon and Out-of-Subbasin Actions (but not with actions in Washington).

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		1.34	650
Base-Current		1.60	864
Current-Prospective (25 yrs future)	Habitat	2.51	1,576
	Hydro	2.81	1,779
	Predation	2.94	1,859
	Estuary	3.11	1,961
	Harvest	3.11	1,961
	Ocean ±25%	2.33-3.88	1,451-2,393

Performance period	Scenario combination	Performance metric	
		Productivity	**Abundance**
Current-Prospective (100 yrs future)	Habitat	2.76	1,730
	Hydro	3.09	1,944
	Predation	3.23	2,027
	Estuary	3.41	2,136
	Harvest	3.41	2,136
	Ocean ±25%	2.56-4.27	1,599-2,590

Touchet River Population

Because of a lack of empirical data for the Touchet River steelhead population, base productivity was estimated as the median of the empirical series of estimates for the Walla Walla and Umatilla populations. This resulted in an estimated productivity of 1.42 for the Touchet population. It is important to note that this value is only a surrogate and will be replaced with an empirically derived estimate after there is a data series of sufficient length.

Abundance and productivity are projected to increase for Touchet River steelhead (Table 9-13). A relatively large contribution to performance improvements should result from tributary habitat actions. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-13 shows estimated population performance (productivity and abundance) of Touchet River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Base productivity was estimated as the median of the empirical series of productivity from the Walla Walla and Umatilla populations. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-13. Estimated productivity and abundance of Touchet River steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric	
		Productivity	Abundance
Base		1.42	310
Base-Current		1.69	387
Current-Prospective (10-15 yrs future)	Habitat	2.97	914
	Hydro	3.33	1,032
	Predation	3.48	1,078
	Estuary	3.67	1,139
	Harvest	3.67	1,139
	Ocean ±25%	2.57-4.59	609-1,402

9.2.4 Yakima MPG

Satus Creek Population (tributary only)

Abundance and productivity are projected to increase for all scenario combinations analyzed for Satus Creek steelhead (Table 9-14). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the major habitat restoration scenario, which assumes that restoration actions will achieve about 50 percent of Properly Functioning Conditions across the watershed. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-14 shows estimated population performance (productivity and abundance) of Satus Creek steelhead (tributary only) associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with minimum habitat restoration actions (using reference conditions described in the Yakima Steelhead Recovery Plan) and major habitat restoration actions (restoring 50 percent of Properly Functioning Conditions across the subbasin). All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25 percent represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-14. Estimated Productivity and Abundance of Satus Creek Steelhead (Tributary only) associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		Minimum habitat restoration	Major habitat restoration	Minimum habitat restoration	Major habitat restoration
Base		1.73	1.73	379	379
Base-Current		2.06	2.06	487	487
Current-Prospective	Habitat	2.29	5.14	540	1,474
	Hydro	2.52	5.63	607	1,624
	Predation	2.63	5.87	639	1,696
	Estuary	2.78	6.19	682	1,793
	Harvest	2.78	6.19	682	1,793
	Ocean ±25%	2.09-3.46	4.70-7.70	478-870	1,338-2,225

Toppenish River Population

Abundance and productivity are projected to increase for all scenario combinations analyzed for Toppenish River steelhead (Table 9-15). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the major habitat restoration scenario, which assumes that restoration actions will achieve about 50 percent of Properly Functioning Conditions across the watershed. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-15 shows estimated population performance (productivity and abundance) of Toppenish River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with minimum habitat restoration actions (using reference conditions described in the Yakima Steelhead Recovery Plan) and major habitat restoration actions (restoring 50 percent of Properly Functioning Conditions across the subbasin). All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-15. Estimated Population Performance (Productivity and Abundance) of Toppenish River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		Minimum habitat restoration	Major habitat restoration	Minimum habitat restoration	Major habitat restoration
Base		1.60	1.60	322	322
Base-Current		2.05	2.05	462	462
Current-Prospective	Habitat	2.32	4.78	564	1,597
	Hydro	2.55	5.23	635	1,760
	Predation	2.66	5.45	670	1,839
	Estuary	2.81	5.75	715	1,944
	Harvest	2.81	5.75	715	1,944
	Ocean ±25%	2.12-3.51	4.37-7.16	499-918	1,448-2,413

Naches River Population

Abundance and productivity are projected to increase for all scenario combinations analyzed for Naches River steelhead (Table 9-16). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the major habitat restoration scenario, which assumes that restoration actions will achieve about 50 percent of Properly Functioning Conditions across the watershed. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-16 shows estimated population performance (productivity and abundance) of Naches River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with minimum habitat restoration actions (using reference conditions described in the Yakima Steelhead Recovery Plan) and major habitat restoration actions (restoring 50 percent of Properly Functioning Conditions across the subbasin). All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-16. Estimated Productivity and Abundance of Naches River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		Minimum habitat restoration	Major habitat restoration	Minimum habitat restoration	Major habitat restoration
Base		1.12	1.12	472	472
Base-Current		1.34	1.34	971	971
Current-Prospective	Habitat	1.63	3.20	1,575	5,427
	Hydro	1.76	3.43	1,860	5,997
	Predation	1.83	3.55	2,002	6,273
	Estuary	1.92	3.71	2,192	6,644
	Harvest	1.92	3.71	2,192	6,644
	Ocean ±25%	1.53-2.36	3.06-4.51	1,347-3,054	4,989-8,320

Upper Yakima River Population

Abundance and productivity are projected to increase for all scenario combinations analyzed for Upper Yakima River steelhead (Table 9-17). The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the major habitat restoration scenario, which assumes that restoration actions will achieve about 50 percent of Properly Functioning Conditions across the watershed. Benefits associated with mainstem actions are cumulative with the sequential addition of actions.

Table 9-17 shows estimated population performance (productivity and abundance) of Upper Yakima River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with minimum habitat restoration actions (using reference conditions described in the Yakima Steelhead Recovery Plan) and major habitat restoration actions (restoring 50 percent of Properly Functioning Conditions across the subbasin). All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 9-17. Estimated Productivity and Abundance of Upper Yakima River Steelhead associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		Minimum habitat restoration	Major habitat restoration	Minimum habitat restoration	Major habitat restoration
Base		1.09	1.09	85	85
Base-Current		1.30	1.30	363	363
Current-Prospective	Habitat	1.46	2.58	923	3,809
	Hydro	1.50	2.62	1,041	4,089
	Predation	1.56	2.72	1,179	4,337
	Estuary	1.64	2.86	1,367	4,672
	Harvest	1.64	2.86	1,367	4,672
	Ocean ±25%	1.32-2.03	2.35-3.53	622-2,259	3,296-6,187

9.3 Aggregate Analysis

This section describes the integration of total "base-to-current" and total "current-to-future" productivity and abundance improvements expected from recovery actions. For simplicity, improvements are based on the benefits of all priority actions projected at ≤ 25 years into the future. In addition, unless noted otherwise, benefits described in this section are based on the least intensive restoration scenarios (e.g., scenarios without passage, without stray actions, etc.). "Overall" abundance/productivity benefits are then compared to the 5 percent risk curves (in a 100-year time period). Information on expected changes to spatial structure and diversity are not currently available.

9.3.1 Cascades Eastern Slope MPG

Productivity. The combined effects of current and future recovery actions should result in productivity increases of at least 14 to 224 percent, compared to the "base" condition for Cascades Eastern Slope populations (Table 9-18). Productivity for the Deschutes Eastside population is expected to increase the most (base to future = 96-224 percent). These percentages do not account for possible increases in productivity that could be gained by reducing the number of stray hatchery fish spawning with naturally produced fish. Productivity for the Deschutes Westside population, which has the largest survival gap in this MPG, is expected to increase 31-118 percent (base-future). These percentages do not include actions for passage (at the Pelton-Round Butte Complex and Whychus Creek) or decreasing the numbers of stray hatchery fish spawning in the population. Including these actions, productivity could be expected to increase 98-230 percent. Productivities in the other populations are expected to increase 14-129 percent.

Abundance. The combined effects of current and future recovery actions should result in abundance increases of at least 9 to 600 percent, compared to the "base" condition for Cascades Eastern Slope populations (Table 9-19). Abundance for the Deschutes Eastside population should increase the most (base to future = 255-600 percent). Abundance in the Deschutes Westside population, which has the largest survival gap in this MPG, should increase 9-85 percent. Including passage and stray actions, the abundance of this population may increase 67-177 percent. The other populations in the MPG are expected to increase 26-170 percent in abundance.

Abundance/Productivity Risk. Only the Deschutes Westside population has an estimated survival gap (78 percent increase in survival needed to achieve 5 percent risk in a 100-year time period under base hydrosystem and recent ocean conditions). Gaps could not be estimated for the Klickitat or Rock Creek populations because of a lack of information. The other two populations (Deschutes Eastside and Fifteen Mile) had no survival gaps and the projected abundance/productivity estimates for these populations fell above the 5 percent risk curves (i.e., risk in a 100-year period was ≤ 5 percent) (Figure 9-1). The proposed actions for the Deschutes Westside population should result in ≤ 5 percent risk (in a 100-year time period) for abundance/productivity if actions intended to decrease the number of stray hatchery fish are implemented and passage is provided at the Pelton-Round Butte Complex. In the absence of stray actions and passage at Pelton-Round Butte, the projected benefit in abundance/productivity may not achieve ≤ 5 percent risk (Figure 9-1, bottom graph).

9.3.2 John Day River MPG

Productivity. The combined effects of current and future recovery actions should result in productivity increases of at least 30 to 188 percent, compared to the "base" condition for John Day populations (Table 9-18). Productivity is expected to increase the most for the Upper Mainstem population (base to future = 77-188 percent). For the South Fork population, which has the largest survival gap in this MPG, productivity is projected to increase 34-121 percent (base-future). For the Lower Mainstem and Middle Fork populations, which also have survival gaps, productivity is projected to increase 54-145 percent and 58-159 percent, respectively. Productivity for the North Fork population, which has no survival gap, is expected to increase 30-115 percent (base-future).

Abundance. The combined effects of current and future recovery actions should result in abundance increases of at least 42 to 440 percent, compared to the "base" condition for John Day populations (Table 9-19). Abundance is expected to increase the most for the Lower Mainstem population (base to future = 180-440 percent). For the South Fork population, which has the largest survival gap in this MPG, abundance is projected to increase 43-157 percent (base-future). For the Middle Fork population, which has a survival gap, abundance is projected to increase 64-189 percent. Abundance for the North Fork and Upper Mainstem populations is expected to increase 42-153 percent and 116-282 percent, respectively.

Abundance/Productivity Risk. The North Fork John Day population is the only population within the John Day MPG that is presently considered viable (at ≤ 5 percent risk in a 100-year period). The other populations within the MPG have survival gaps (Table 9-3). The proposed actions for all populations within this DPS should result in ≤ 5% risk (in a 100-year time period) for abundance/productivity (Figure 9-2).

9.3.3 Umatilla/Walla Walla MPG

Productivity. The combined effects of current and future recovery actions should result in productivity increases of at least 93 to 221 percent, compared to the "base" condition for the Umatilla and Walla Walla populations (Table 9-18). Productivity for the Walla Walla population, which has the largest survival gap in this MPG, is projected to increase 93-221 percent (base-future). For the Umatilla population, which has a survival gap, productivity is also expected to increase 93-221 percent. For the Touchet River, base productivity was estimated as the median of the empirical series of estimates for the Walla Walls and Umatilla populations. This is a surrogate value and will be replaced with an empirically derived estimate after there is a data series of sufficient length. Based on this interim value, productivity is expected to increase 52-172 percent (base-future).

Abundance. The combined effects of current and future recovery actions should result in abundance increases of at least 125 to 433 percent, compared to the "base" condition for Umatilla and Walla Walla populations (Table 9-19). Abundance for the Walla Walla population, which has the largest survival gap in this MPG, is projected to increase 213-433 percent (base-future). For the Umatilla population, which has a survival gap, abundance is also expected to increase 125-287 percent. Abundance for the Touchet population is expected to increase 57-262 percent.

Abundance/Productivity Risk. Of the three populations within the Umatilla/Walla Walla DPS, there are estimated survival gaps for the Umatilla and Walla Walla populations (Table 5-1). A gap for the Touchet population could not be estimated because of a lack of information. The proposed restoration actions for the Umatilla and Walla Walla populations should result in ≤ 5% risk (in a 100-year time period) for abundance/productivity (Figure 9-3). Assuming a base productivity of 1.42 for the Touchet population (this is the median of the Walla Walla and Umatilla populations) and a projected productivity and abundance of 3.67 and 1,139, respectively, the proposed restoration actions for the Touchet population should result in ≤ 5% risk.

9.3.4 Yakima MPG

Productivity. The combined effects of current and future recovery actions should result in productivity increases of at least 21 to 119 percent, compared to the "base" condition for Yakima populations (Table 9-18). Productivity is expected to increase the most for the Toppenish population (base to future = 33-119 percent). Productivity for the Upper Yakima, which has the largest survival gap in this MPG, is projected to increase 21-86 percent (base-future). For the other two populations, which also have survival gaps, productivity is expected to increase 21-100 percent for the Satus Creek population (tributary only) and 37-111 percent for the Naches population.

Abundance. The combined effects of current and future recovery actions should result in abundance increases of at least 26 to 2,558 percent, compared to the "base" condition for Yakima populations (Table 9-19). The largest increase in abundance is projected for the Upper Yakima population (base to future = 632-2,558 percent). Abundance for the Satus Creek population is projected to increase 26-130 percent (base-future). Abundance for the Toppenish and Naches populations should increase 55-185 percent and 185-547 percent, respectively.

Abundance/Productivity Risk. Under the major restoration scenario, all populations are expected to achieve ≤ 5% risk (in a 100-year time period) for abundance/productivity (Figure 9-4). Under the minimum restoration scenario, however, only the Naches and Toppenish populations are projected to achieve ≤ 5% risk for abundance/productivity.

9.4 Summary of Expected Benefits of Proposed Actions for Middle Columbia Steelhead DPS

Based on the proposed actions identified within the specific management unit plans, all Middle Columbia River steelhead populations for which there are adequate data are expected to achieve less than 5% risk for abundance/productivity if the most intensive (major) restoration scenarios are implemented (Figure 9-5). Under minimum restoration scenarios, three populations (Deschutes Westside, Satus (tributary only), and Upper Yakima populations) may not achieve ≤ 5% risk for abundance/productivity. However, even under poor ocean conditions and minimum restoration actions, the abundance and productivity of these three populations are expected to increase considerably over base conditions (Tables 9-18 and 9-19).

Table 9-18 shows total changes in productivity of Middle Columbia River steelhead expected from current and prospective recovery actions. For Oregon populations and the Walla Walla and Touchet, total changes in productivity are based on benefits projected at ≤ 25 years into the future. The range of benefits represents performance of combined actions under relatively poor (-25%) and good (+25%) ocean conditions. Estimates greater than 1.00 result in higher productivity (e.g., 1.114 indicates an 11.4% increase in productivity, compared to the base period average); 1.00 indicates no change; and estimates less than 1.00 result in lower productivity.

Table 9-18. Total changes in Productivity of Middle Columbia River Steelhead expected from Current and Prospective Recovery Actions.

Major Population Group	Population	Total Base-to-Current	Total Current-to-Future (±25% Ocean)	Total Base-Current and Current-Future[1] (±25% Ocean)
Cascades Eastern Slope	Deschutes W.[2]	1.114	1.179-1.957	1.313-2.180
	Deschutes E.[3]	1.111	1.767-2.919	1.963-3.243
	Klickitat[4]	1.085	1.047-1.375	1.136-1.492
	Fifteen Mile	1.077	1.276-2.128	1.374-2.291
	Rock Creek[5]	1.134	1.214	1.377
John Day	Lower Mainstem	1.151	1.340-2.131	1.542-2.452
	North Fork	1.149	1.134-1.870	1.303-2.149
	Middle Fork	1.151	1.376-2.252	1.584-2.592
	South Fork	1.150	1.165-1.920	1.340-2.209
	Upper Mainstem	1.150	1.541-2.504	1.771-2.879
Umatilla/Walla Walla	Umatilla	1.153	1.676-2.786	1.933-3.213
	Walla-Walla	1.194	1.613-2.688	1.925-3.209
	Touchet[6]	1.190	1.521-2.716	1.810-3.232

Major Population Group	Population	Total Base-to-Current	Total Current-to-Future (±25% Ocean)	Total Base-Current and Current-Future[1] (±25% Ocean)
Yakima	Satus (tributary only)[7]	1.191	1.015-1.680	1.208-2.000
	Toppenish[7]	1.281	1.034-1.712	1.325-2.193
	Naches[7]	1.196	1.142-1.761	1.366-2.107
	Upper Yakima[7]	1.193	1.015-1.562	1.211-1.862

[1] Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier.

[2] Represents the no passage and no stray action scenario.

[3] Represents the no stray action scenario.

[4] Represents actions without recolonization of the upper watershed.

[5] Benefits for Rock Creek steelhead were based on the FCRPS BiOp, which did not calculate survival changes under relatively good and poor ocean conditions.

[6] Base productivity for the Touchet population was estimated as the median of the empirical series of estimates for the Umatilla and Walla Walla populations. The base estimate for the Touchet is only a surrogate that will be replaced with an empirically derived estimate after there is a data series of sufficient length.

[7] Represents the minimum habitat restoration scenario.

Table 9-19 shows total changes in abundance of Middle Columbia River steelhead expected from current and prospective recovery actions. For Oregon populations and the Walla Walla and Touchet, total changes in abundance are based on benefits projected at ≤ 25 years into the future. The range of benefits represents performance of combined actions under relatively poor (-25%) and good (+25%) ocean conditions. Estimates greater than 1.00 result in higher abundance (e.g., 1.114 indicates an 11.4% increase in abundance, compared to the base period average); 1.00 indicates no change; and estimates less than 1.00 result in lower abundance. NA = information not available.

Table 9-19. Total changes in abundance of Middle Columbia River steelhead expected from current and prospective recovery actions.

Major Population Group	Population	Total Base-to-Current	Total Current-to-Future (±25% Ocean)	Total Base-Current and Current-Future[1] (±25% Ocean)
Cascades Eastern Slope	Deschutes W.[2]	1.127	0.967-1.642	1.090-1.851
	Deschutes E.[3]	1.463	2.427-4.786	3.552-7.004
	Klickitat[4]	1.191	1.056-1.812	1.258-2.158
	Fifteen Mile	1.087	1.433-2.484	1.558-2.699
	Rock Creek[5]	NA	NA	NA
John Day	Lower Mainstem	1.346	2.083-4.012	2.804-5.401
	North Fork	1.207	1.173-2.096	1.417-2.531
	Middle Fork	1.218	1.346-2.374	1.640-2.892
	South Fork	1.216	1.171-2.111	1.425-2.568
	Upper Mainstem	1.240	1.737-3.083	2.155-3.824
Umatilla/Walla Walla	Umatilla	1.236	1.820-3.128	2.251-3.868
	Walla-Walla	1.329	2.353-4.010	3.128-5.331
	Touchet	1.248	1.574-3.623	1.965-4.523
Yakima	Satus (tributary only)[6]	1.285	0.982-1.786	1.261-2.296
	Toppenish[6]	1.435	1.080-1.987	1.550-2.851
	Naches[6]	2.057	1.387-3.145	2.854-6.470
	Upper Yakima[6]	4.271	1.714-6.223	7.318-26.576

[1] Calculated as the product of the Total Current-to-Future multiplier and the Total Base-to-Current multiplier.

[2] Represents the no passage and no stray action scenario.

[3] Represents the no stray action scenario.

[4] Represents actions without recolonization of the upper watershed.

[5] Benefits for Rock Creek steelhead were based on the FCRPS BiOp, which did not calculate survival changes under relatively good and poor ocean conditions.

[6] Represents the minimum habitat restoration scenario.

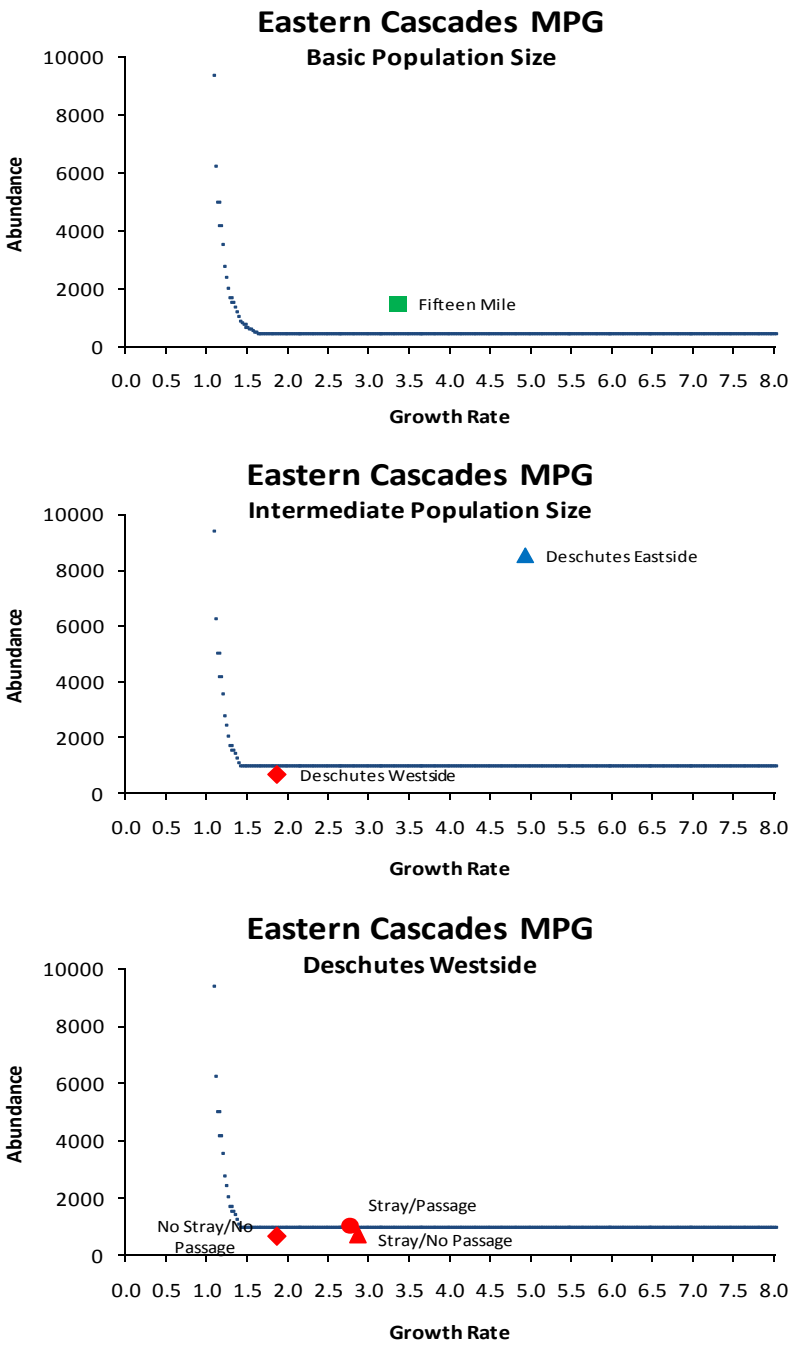


Figure 9-1. Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves (in a 100-year time period) for the different size Steelhead Populations within the Cascades Eastern Slope MPG.

In the top two graphs, estimated benefits (projected 25 years into the future) are associated with the least intensive restoration scenarios. The bottom figure shows the projected benefits associated with the different restoration scenarios for the Deschutes Westside population.

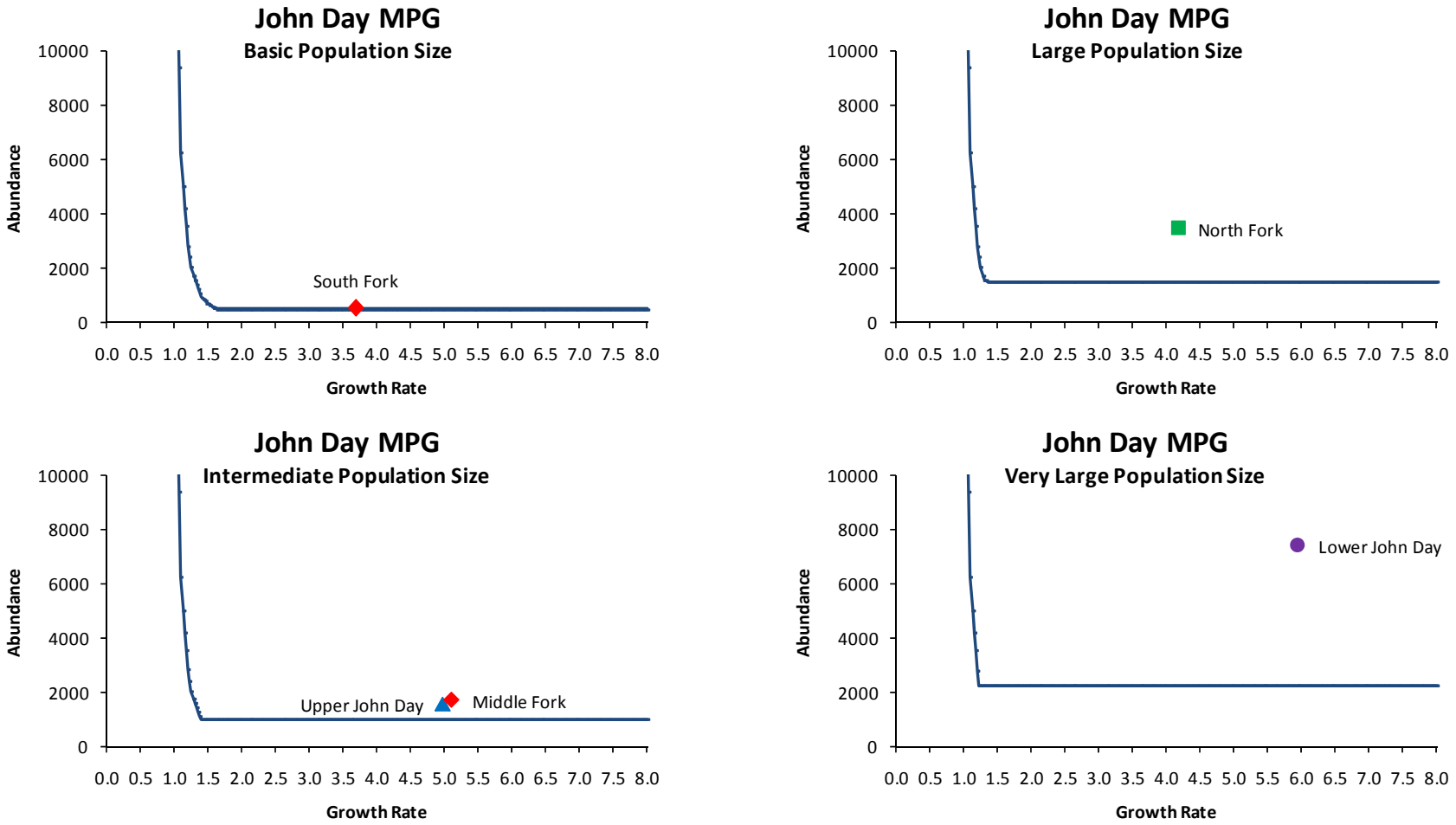


Figure 9-2. Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves (in a 100-year time period) for the different size Steelhead Populations within the John Day MPG. Estimates are projected at 25 years into the future. Populations are considered viable if the projected abundance/productivity estimates fall on or above the 5% risk curve.

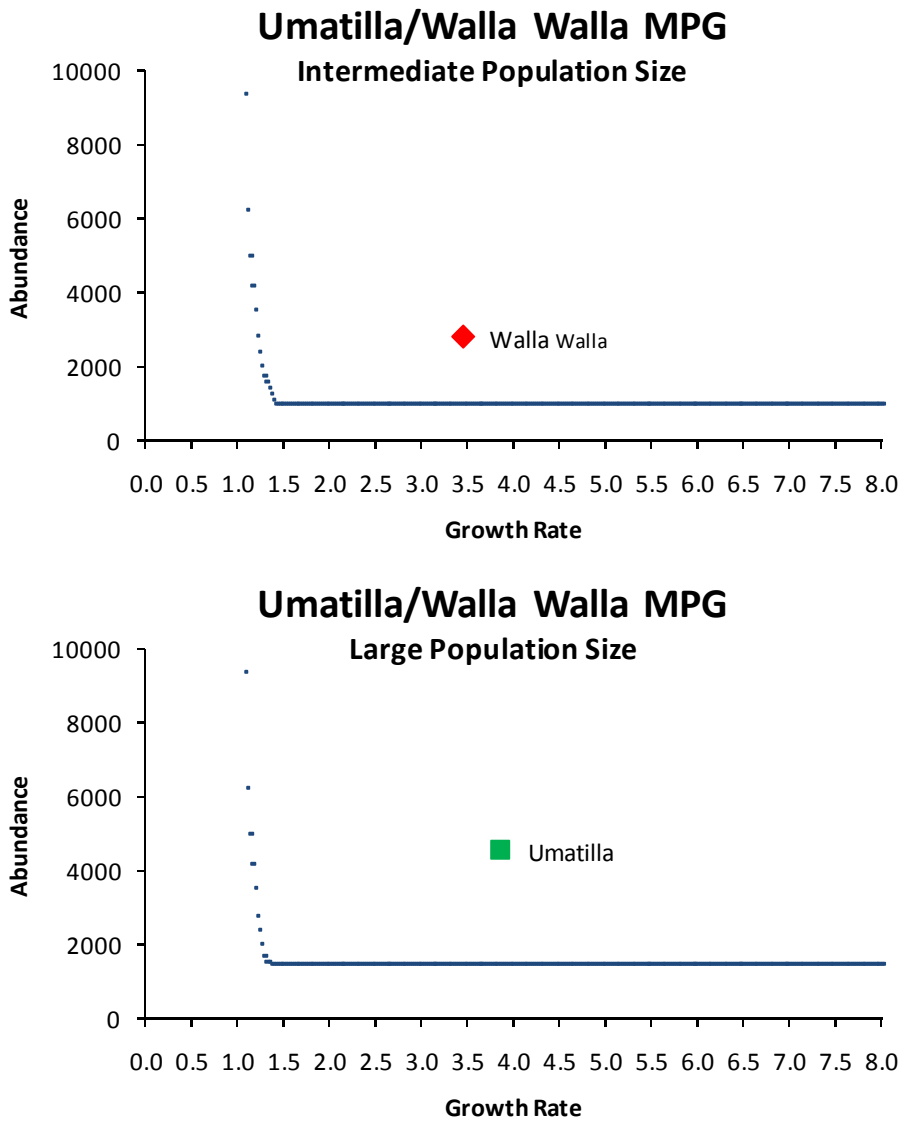


Figure 9-3. Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves (in a 100-year time period) for the different size Steelhead Populations within the Umatilla/Walla Walla MPG. The Walla Walla estimate includes restoration actions within both Oregon and Washington. Estimates are projected at 25 years into the future. Populations are considered viable if the projected abundance/productivity estimates fall on or above the 5% risk curve.

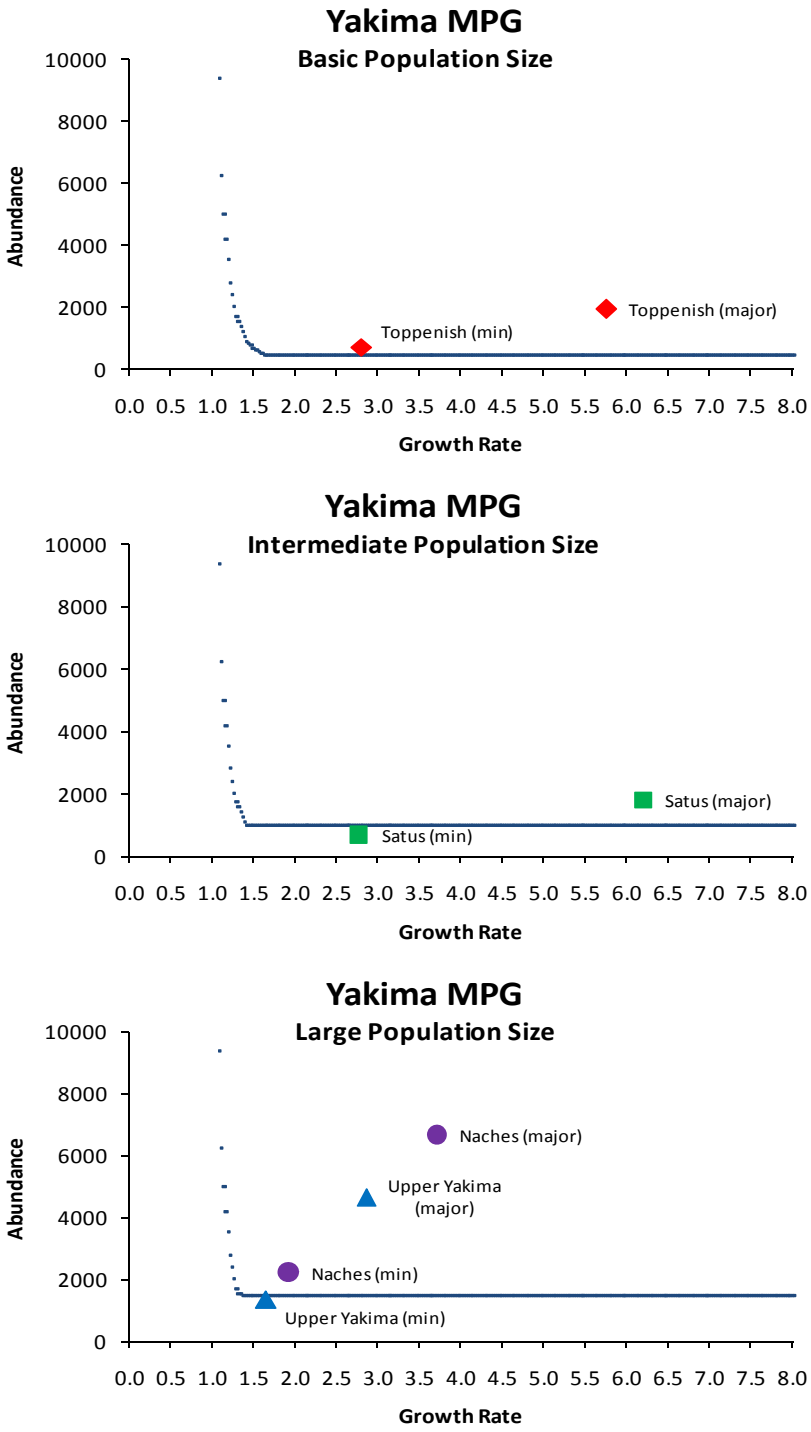


Figure 9-4. Relationship of Projected Abundance/Productivity estimates to 5% Risk Curves (in a 100-year time period) for the different size Steelhead Populations within the Yakima MPG. Estimates from both minimum and major restoration actions are shown for each population. Populations are considered viable if the Projected Abundance/Productivity Estimates fall on or above the 5% Risk Curve.

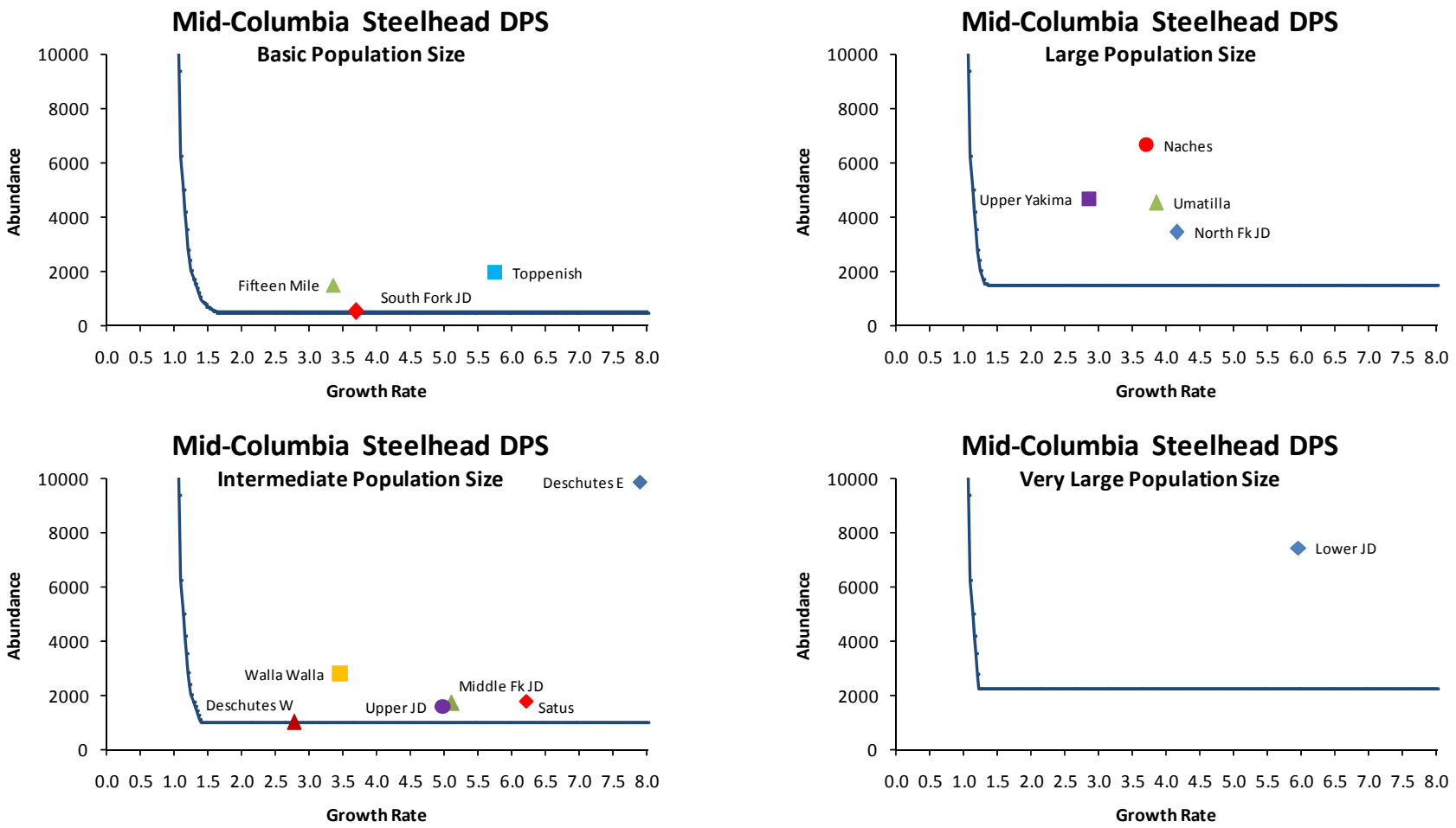


Figure 9-5. Relationship of Projected Abundance/Productivity Estimates to 5% Risk Curves (in a 100-year time period) for the different size Steelhead Populations within the Middle Columbia DPS. Estimates are projected at 25 years into the future and assume major restoration actions. Populations are considered viable if the projected abundance/productivity estimates fall on or above the 5% risk curve.

10. RESEARCH, MONITORING AND EVALUATION FOR ADAPTIVE MANAGEMENT

Because of the length and complexity of the salmonid life cycle and the habitat conditions these anadromous fish require, there are many uncertainties involved in improving salmon or steelhead survival. Simply identifying cause-and-effect relationships between any given management action and characteristics of fish populations can be a scientific challenge. It is essential to design a monitoring and evaluation program that will answer these basic questions: How will we know we are making progress? How will we get the information we need? And how will we use the information in decision-making?

Within the Middle Columbia Basin, many different organizations, including Federal, state, tribal, local, and private entities, currently conduct programs and actions designed to improve tributary fish habitat, and these entities also conduct various kinds of monitoring. Development of Middle Columbia regional coordination will be essential for NMFS' future status reviews of the steelhead DPS. Establishing stable funding and staff to produce annual reports is also important.

Detailed research, monitoring, and evaluation (RM&E) and adaptive management plans need to be developed for each management unit, based on the principles and concepts laid out in the NMFS draft guidance document, *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance* (http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf). Each of the management unit Recovery Plans includes an RM&E component that follows or is generally consistent with the NMFS guidance document. The Oregon management unit plan is organized around a set of key RM&E questions applied to each MPG and includes a comprehensive set of recommendations addressing status monitoring, limiting factors assessments, and responses to recovery actions. The SE Washington management plan RM&E section is tailored after Washington state protocols, which share many of the principles included in the NMFS guidance document. The Yakima and Klickitat management unit plans explicitly incorporate the NMFS RM&E guidance principles and identify opportunities for improved status, limiting factors, and key uncertainty assessments. The Rock Creek Plan RM&E section recognizes that steelhead monitoring information has not been routinely collected in the basin and identifies a set of questions to inform monitoring implementation decisions. All of the management unit RM&E plans call for establishing a more detailed and specific RM&E implementation plan after the corresponding recovery plans are finalized.

The Middle Columbia Science Team will combine these management unit plans into an RM&E and adaptive management plan for the Middle Columbia steelhead DPS. This will ensure that, taken together, the monitoring and evaluation programs for each management unit, combined with monitoring components of the modules incorporated into the plans, address the needs of the entire DPS. The Mid-C Forum and others will use the RM&E and adaptive management plans to guide projects and programs during implementation.

10.1 Designing a Monitoring and Evaluation Program to Support Adaptive Management for Recovery Plans

Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. It is a process of adjusting management actions and/or directions based on new information. To do this, it is essential to incorporate a plan for monitoring, evaluation, and feedback into an overall implementation plan for recovery. The plan should link results (intermediate or final) to feedback on design and implementation of actions. Adaptive management works by coupling the decision-making process with collection of performance data and its evaluation. Most importantly, it works by offering an explicit process through which alternative strategies to achieve the same ends are proposed, prioritized, and implemented when necessary.

An adaptive management plan must include the following elements (Anderson, 2003):

- Management strategies that are revisited regularly;
- The use of conceptual or quantitative models of the system being managed to develop and test hypotheses and to guide strategy and action planning;
- A range of potential management actions that could be used to meet the strategy;
- Monitoring and evaluation to track progress;
- Mechanisms for incorporating learning from monitoring and evaluation into decisions on actions and strategies; and
- A collaborative structure for stakeholder participation in adjusting management strategies and actions.

Adaptive management is crucial for salmonid recovery programs because of the length and complexity of the salmonid life cycle and the uncertainties involved in improving salmonid survival and status. The key is to build explicit links between management actions, monitoring data, and biological and physical responses.

Several types of monitoring are needed to support adaptive management:

- Implementation and compliance monitoring, used to evaluate whether the recovery plan is being implemented.
- Status and trend monitoring, which assesses changes in the status of an ESU and its component populations, and changes in status or significance of the threats to the ESU.
- Effectiveness monitoring, which tests hypotheses on cause-and-effect relationships and determines (via research) if an action is effective and should be continued.

It is essential to build effectiveness monitoring into the implementation plan at the outset, because it requires explicitly coupling the monitoring design and implementation with the action design and implementation in order to detect an effect. Recovery plan implementation should consist of action strategies that include the demonstration of effect.

It is also important to explicitly address the many unknowns in salmon recovery – the "critical uncertainties" that make management decisions much harder. Critical uncertainty research may seem expensive or unnecessary in light of basic information needs; however, in the long run, it

will reduce monitoring and implementation costs. Critical uncertainties are described in more detail in Section 10.3, below.

Implementation and compliance monitoring simply check on whether activities were carried out as planned, and whether specified criteria are being met as a direct result of an implemented action. For example, if a fence is planned for 20 miles of stream corridor to keep livestock off the stream banks so that riparian vegetation will rebound, implementation monitoring would verify the presence of the fence. Compliance monitoring would take note of the presence or absence of livestock in the fenced-off area.

Status and trend monitoring is a simple compilation of data-based descriptions of existing conditions. To be useful in decision-making, the raw data, or metrics, must be reduced to a more directly applicable form or indicator. For example, if the question is "What is the annual spawning population size of steelhead in the X River?" the indicator would be total spawning numbers of steelhead over one season for the entire river basin; however, the metric, or directly measured thing, would be something quite different, perhaps steelhead redds sighted on weekly passes over known spawning grounds. Thus, the metric must be processed to translate it from the metric data type (e.g., redds) into the indicator data type (e.g., spawners), and then reduced to generate the indicator required (e.g., list of weekly counts on spawning grounds to annual total for watershed). The ICTRT identified deficiencies in the currently available data and/or data-gathering techniques for Middle Columbia River steelhead. These are described in Section 10.4, below.

Effectiveness monitoring specifically addresses cause-and-effect questions. Demonstrating the direct and indirect impact of management actions requires supporting all steps in the logical chain that connects the action to its expected impact. This chain is rarely short and usually contains several hypotheses. For this reason, it's better to build the effectiveness monitoring into the recovery action strategies, with, for example, pilot-scale tests or other methods carefully thought out beforehand. Monitoring and evaluation will only provide the answers to the questions they were designed to address; they do not provide the framework for revising these questions if they are ill-posed, evaluating the assumptions upon which the strategy was built, or incorporating learning into future decisions on actions and strategies—this is the role of adaptive management.

NMFS' guidance document presents a decision framework that can guide the design of a research, monitoring, and evaluation plan. The framework (Figure 10-1) contains two basic sorts of questions: (1) questions regarding ESU status (biological viability criteria) and (2) questions regarding statutory listing factors and factors limiting recovery (limiting factor and threats criteria). Evaluating a species for potential delisting requires an explicit analysis of both types of criteria.

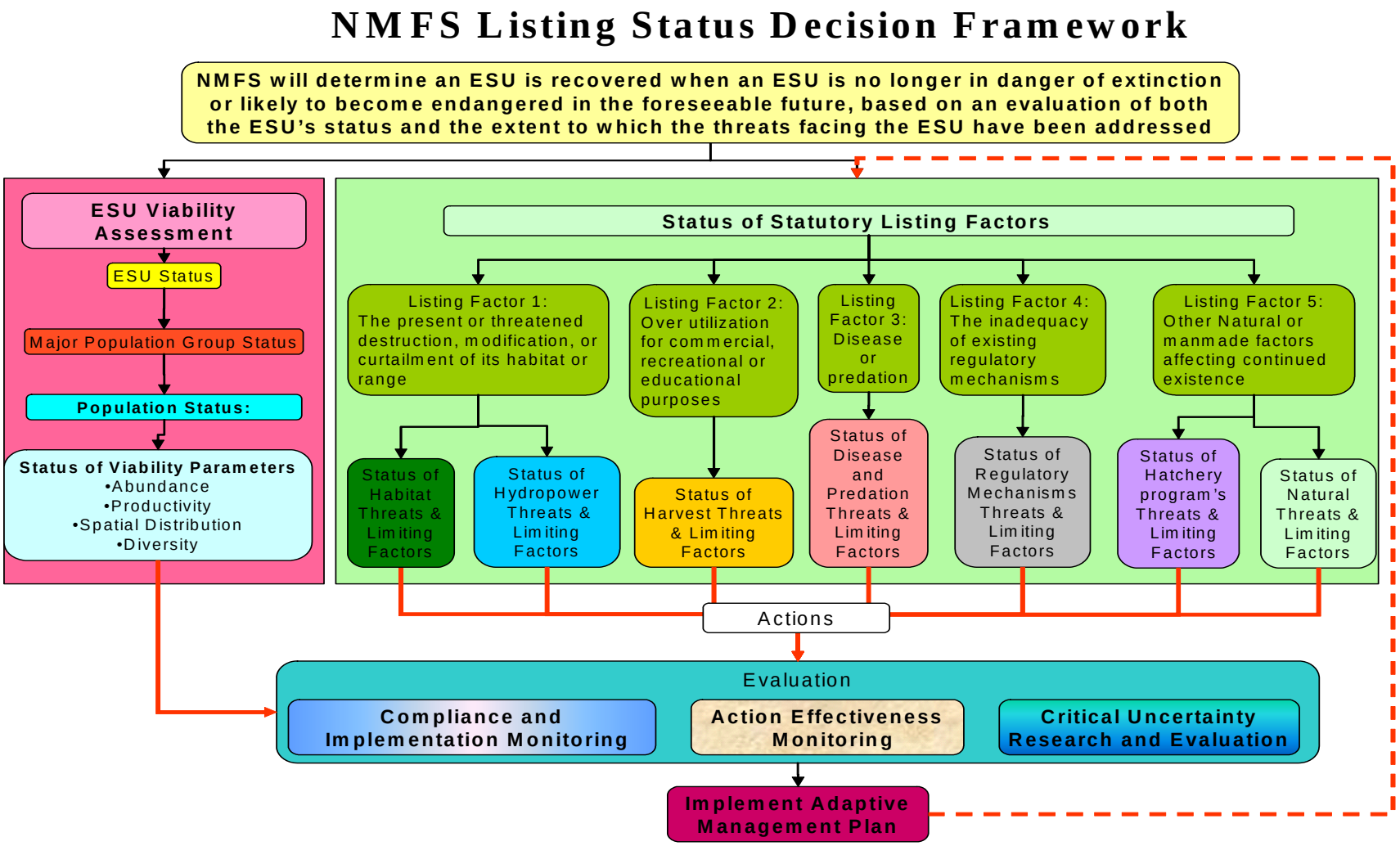


Figure 10-1. NMFS Listing Status Decision Framework

The guidance document contains a more detailed discussion of the framework and identifies the specific questions that must be answered to evaluate ESU status. These specific questions take the form of a series of decision-question sets that address the status and change in status of a salmonid ESU and the risks posed by threats to the ESU. The decision-question sets are designed to elicit the information NMFS needs to make delisting decisions. The framework can guide future decisions about strategies and actions aimed at achieving population, MPG, and ESU recovery goals.

Designing an effective monitoring program for salmon recovery involves the following initial steps:

1. Clarify the questions that need to be answered for policy and management decision-making. Include the full ESU and the full salmonid life cycle.
2. Identify entity or entities responsible for coordinating development of this program.
3. Identify:
    - Which populations and associated limiting factors to monitor
    - Metrics and indicators
    - Frequency, distribution, and intensity of monitoring
    - Tradeoffs and consequences of these choices
4. Assess the degree to which existing monitoring programs are consistent with NMFS guidance.
5. Identify needed adjustments in existing programs, additional monitoring needs, and strategy for filling those needs.
6. Develop a data management plan (See Appendix C of the NMFS guidance document).
7. Prioritize research needs for critical uncertainties, testing assumptions, etc.
8. Identify entities responsible for implementation.

Monitoring and evaluation programs will provide (1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed, (2) a plan for tracking such metrics and indicators, and (3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the Plan's goals.

10.2 Five-Year Reviews, ESU/DPS Status Assessments, and Adaptive Management

The ESA requires that, at least every 5 years, the Secretary shall conduct a review of all ESA-listed species and determine whether any species should: (1) be removed from such list; (2) be changed in status from an endangered species to a threatened species; or (3) be changed in status from a threatened species to an endangered species. Accordingly, at five-year intervals, NMFS will conduct reviews of the Middle Columbia steelhead DPS. These reviews will consider information that has become available since the most recent listing determinations, and make recommendations whether there is substantial information to suggest that a change in listing status may be warranted. If an ESU or DPS may warrant a change in status NMFS will conduct a formal, much more in-depth, ESA status review consistent with section 4(a) of the Act. Any formal status reviews will be based on the NMFS Listing Status Decision Framework and will be informed by the information obtained through implementation of the monitoring, research, and evaluation programs in each management unit plan and the recovery modules.

Similarly, new information considered during the five-year reviews may also compel more in-depth assessments of implementation and effectiveness monitoring and associated research to inform adaptive management decisions at the management unit and module level.

10.3 Research on Key Uncertainties

Chapter 6 described many of the important factors that have reduced, and continue to reduce, the abundance, productivity, spatial structure, and diversity of Middle Columbia River steelhead. It is clear that actions must be taken in all sectors (not just habitat) in order to recover listed populations. However, there are "key" areas of uncertainty identified in Biological Opinions (BiOp), PATH (Plan for Analyzing and Testing Hypotheses), and Northwest Power and Conservation Council documents that can affect the success of actions implemented within each of the sectors. Resolution of uncertainties will greatly improve chances of attaining recovery goals outlined in this plan. These "key" uncertainties are highlighted below.

10.3.1 Ocean Productivity and Natural Variation

Global-scale processes in the ocean and atmosphere can regulate the productivity of marine, estuarine, and freshwater habitats of steelhead. Although managers cannot control these processes, natural variability must be understood to correctly interpret the response of steelhead to management actions. For example, assessing needed survival improvements based on spawner returns during periods of below average climatic and other background conditions has the effect of projecting these generally poor ocean conditions into the future. If one were to add years representing better ocean conditions to the analysis, estimated required survival increases would decrease. Additional research is needed to help understand the mechanisms of ocean and climatic survival conditions, and to help improve forecasting and relating fisheries management capabilities and ensure that Middle Columbia steelhead populations persist over the full range of environmental conditions they are likely to encounter.

10.3.2 Global Climate Change

The potential impacts of global climate change are recognized at national and international levels. Many climate models project changes in regional snowpack and stream flows with global climate change. The effects of these changes could have significant effects on the success of recovery actions and the status of Middle Columbia steelhead. The risks of global climate change are potentially great for Middle Columbia stocks because many of the populations spawn and rear in snow-rain transitional zones that are likely to be impacted by climate change. It will be important to monitor key environmental variables such as summer and fall streamflow and temperature in tributaries (Crozier et al. 2008) and to perform research to better understand the relation between changes in those habitat factors and survival of Middle Columbia steelhead. Other useful freshwater monitoring includes assessment of existing areas of hyporheic flow comprising cold-water refuges and research to understand how those areas change with environmental conditions and human impacts such as water withdrawals. Steelhead stocks are also sensitive to climate-related shifts in ocean conditions, such as the position of the sub-arctic boundary, the strength of the California Current, the intensity of coastal upwelling, and the frequency and intensity of El Nino events (NPCC 2004). More research is needed to address the effects of climate change on ocean circulation patterns, freshwater habitat, and steelhead productivity.

10.3.3 Hatchery Effectiveness

Uncertainties exist regarding the potential for both benefits and harm of hatchery-produced fish on naturally spawning steelhead populations. A major uncertainty is whether it is possible to integrate natural and artificial production systems in the same subbasin to achieve sustainable long-term productivity. There is also uncertainty about the reproductive success of hatchery fish spawning in the wild. There is currently little data available and experimental methods for obtaining this information will take many years to get initial results and much longer before conclusions can be inferred from the empirical information. Although supplementation is considered a potential benefit to recovery, it carries risks as noted here.

10.3.4 Differential Delayed Mortality of Transported Steelhead (D Value)

The differential delayed mortality of transported steelhead (D value) is the estimated ratio of the post-Bonneville survival of transported fish relative to in-river migrating fish. This differential mortality can occur during any time from release downstream from Bonneville Dam, through the estuary and ocean life stage, and during adult upriver migration to the specific dam from which they were transported. The factors determining D are complex and poorly understood. This uncertainty has little effect under current conditions because few Middle Columbia steelhead are currently transported. However, an improved understanding of D will be necessary to determine the appropriate role of McNary transportation in the future. Furthermore, the future role of transportation and the potential benefit of major hydro-system configurations are highly sensitive to this uncertainty.

10.3.5 Invasive Species

Another critical uncertainty is the effect of invasive species on the viability of Middle Columbia steelhead. One such species, American shad, may affect the abundance and survival of steelhead in the lower Columbia River. It is possible that the growing population of shad is competing directly with juvenile steelhead by cropping food sources important to salmonids in the lower Columbia River. It is also possible that the large numbers of shad in the lower river contribute to the growth of northern pikeminnow, smallmouth bass, and walleye, which are important predators of steelhead. Shad may be sustaining large populations of predators during periods when steelhead are not available to the predators, and, as a result, more and larger predators are present during periods when steelhead are moving through the lower Columbia River.

10.3.6 Independent Populations

The Interior Columbia Basin Technical Recovery Team (ICBTRT) used a hierarchical approach to define DPS level viability, defining independent populations within each DPS and applying relatively simple rule sets to geographic groups of those populations to evaluate viability (ICBTRT 2003). The ICBTRT based their approach on the guidelines provided in McElhany et. al. (2000), including a specific definition of an independent population (see Section 2.2.3).

Following McElhany et al. (2000), the ICTRT assumed that spawning aggregations meeting a minimum size criteria were defined as independent if they were separated by a sufficient distance so that expected straying rates would be below 5-10 percent (ICBTRT 2003).

The ICBTRT DPS status evaluations were based on simplified demographic analyses of individual populations that implicitly assume that each population would function independently. The hierarchical model of DPS structure recognizes that relatively low (<10%) levels of exchange among independent populations within a DPS is also important to overall DPS viability.

The ICBTRT ESU/DPS level criteria were specifically designed to "... ensure preservation of basic historical metapopulation processes including:1) genetic exchange across populations within an ESU over a long time frame; 2) the opportunity for neighboring populations to serve as source areas in the event of local population extirpations; 3) populations distributed within an ESU so that they are not all susceptible to a specific localized catastrophic event. To meet these objectives a viable ESU will likely have some populations meeting viability standards close to each other AND some populations meeting viability standards relatively distant from each other (McElhany et al. 2000, Isaak et al. 2003)."

The ICBTRT viability criteria were specifically designed to implement the principles in McElhany et al. 2000 given the range of characteristics and data availability associated with listed Interior Columbia ESU/DPS. As the ICBTRT acknowledged, it may be possible to develop more detailed metapopulation models for DPS/ESUs where sufficient information is available. Continuing to explore each ESU/DPS from a metapopulation perspective could lead to improved criteria for assessing the risk at the DPS level. For that purpose, research is needed to further define population structures, natural straying, and movement among aggregations.

10.3.7 Effects of Interacting Strategies/Actions

A critical uncertainty associated with the implementation of this recovery plan will be the effect of management actions or strategies on the environment and on life-stage specific survival rate and population level responses. It is unclear how strategies implemented within each of the sectors (Harvest, Hatcheries, Hydropower, and Habitat) will interact and contribute to recovery. In particular, a high level of uncertainty exists for the magnitude and response time of habitat actions. Even if all habitat actions could be implemented immediately (which they cannot), there will be delays in the response to actions. Populations will likely respond more quickly to some actions (e.g., diversion screens and barrier removals) than they will to others (e.g., riparian plantings). Although the effects of interacting strategies on population VSP parameters remain unknown, monitoring will contribute substantially to resolving this uncertainty.

10.3.8 Effects of Human Population Growth

Human population growth in the Columbia Basin and its effects on recovery of listed species is a critical uncertainty. The size of the human population within the Columbia Basin will continue to increase and projected development will probably expand along streams and rivers at a greater rate than in upland areas. A high degree of coordination among agencies, tribes, and counties will be needed to maximize recovery efforts.

10.3.9 Resident-Anadromous *O. mykiss* Interactions

In the Middle Columbia region, only the anadromous life form (steelhead) of *O. mykiss* is listed. The resident life form (also known as rainbow trout or redband trout) is not listed, although these fish are genetically similar to steelhead, where they co-occur. In addition, where they co-occur,

individuals can occasionally produce progeny of the alternative life form. The nature of the relationship between resident and anadromous forms of *O. mykiss* is inherently complex, and an improved understanding of the range of interactions is needed.

10.4 Important Data Gaps

The management unit plans described monitoring and research needs for each steelhead population and/or area, and will do so in greater detail in the RM&E plans that will be completed after the DPS plan is approved. In its 2007 document, "Viability Criteria for Application to Interior Columbia Basin Salmonid ESUs," the ICTRT identified data gaps at the DPS/MPG level. The ICTRT said: "There is considerable variability in the quality and quantity of information to conduct viability assessments for Interior Columbia River salmon and steelhead populations. We have identified fairly large gaps in information for steelhead populations . . . We believe improving the quality and quantity of data is essential for monitoring future change in population status relative to viability criteria (ICTRT 2007)." Important information gaps the ICTRT listed for conducting population level viability assessments for Middle Columbia River steelhead include the following:

10.4.1 Abundance and Productivity

Mid Columbia Steelhead population abundance and productivity data: Most population abundance estimates are derived from standard index redd count surveys. Yakima population abundance is estimated from aggregate dam counts, and population-specific levels are apportioned using limited radio tag data. Abundance estimates need to be conducted using probabilistic sampling protocol for either redd counts or tagging studies (ICTRT 2007).

Mid Columbia steelhead population specific hatchery fraction and age structure data: A majority of populations had inadequate hatchery fraction information. Abundance and productivity assessments would improve with more detailed population level hatchery fraction data. A majority of populations had inadequate age structure information. Typically, average MPG aggregate age structure from a few years of data was used in most cases for the population level (ICTRT 2007).

Smolt-to-adult returns (SARs) and juvenile productivity estimates: Improve or collect information on SARs and juvenile productivity (i.e. smolts per spawner). SARs are essential for taking into account variability in survival during smolt outmigration and marine life stages in evaluating abundance and productivity criteria. The goal is to estimate SARs that are representative at the population level. There are a number of approaches to accomplish estimating these SARs (e.g. marking wild or hatchery smolts or estimating natural-origin smolts and adult production). In addition, measures representing survival from spawning to outmigrating smolts would aid in partitioning productivity between freshwater and marine life-stages (ICTRT 2007).

Population level effects of hatchery spawners on natural productivity: For populations with hatchery spawners, develop representative estimates of the effects of hatchery spawners on population-level productivity. Topics of interest include the effect of hatchery spawner contributions to the average natural productivity of a population and the relative effectiveness of hatchery spawners. In combination with adequate estimates of the relative levels of hatchery fish

contributing to natural spawning for a particular population, this information would allow for more representative estimates of current and potential natural productivity levels (ICTRT 2007).

10.4.2 Spatial Structure and Diversity

Steelhead population spawner distribution and habitat preference data: Many populations had inadequate spawner distribution information to assess spatial structure and diversity criteria. In addition, estimates of historical distribution are dependent upon habitat preferences derived from available empirical studies. Those studies are limited in scope and number. Additional information on habitat/steelhead preference or production relationships could improve the assessment of steelhead populations against SS/D criteria (ICTRT 2007).

Phenotypic characteristics for populations: Little information was available to assess phenotypic changes. Representative estimates of current morphological, life history, or behavioral traits are not available for many populations. Additional analysis of relationships between habitat characteristics and phenotypic traits would improve the ability to assess changes from historical patterns at the population level (ICTRT 2007).

Genetics information: Genetic baseline information and periodic follow-up surveys specifically designed to evaluate the level of variation or differentiation among subcomponents within populations and among populations. Periodic follow-ups would support evaluation of responses to management actions designed to promote restoration of natural patterns of population structure (ICTRT 2007).

Spawner composition for steelhead populations with hatchery spawners: Collect specific spawner composition information including proportion and source of hatchery spawners. Information on the relative distribution of hatchery spawners among production areas within populations would also improve the ability to assess status against ICTRT spatial structure criteria (ICTRT 2007).

Selective mortality effects: Little information was available to assess selective mortality resulting from differential impacts of human induced mortality. Additional information is needed to better assess human induced mortality effects in each of the four Hs (habitat, hatcheries, harvest and hydropower) (ICTRT 2007).

11. IMPLEMENTATION AND COORDINATION

This chapter describes how implementation of this recovery plan will be coordinated. It proposes that the Middle Columbia Recovery Forum (Mid-C Forum or Forum) will play a central role at the DPS-level.[42] The Forum is a voluntary organization of Federal agencies, states, tribes and other planning entities (see Chapter 1), that will coordinate implementation within the DPS. The function, membership, processes and organization of the Forum are described herein. State entities will play a central role in coordination plan implementation at the MU level. This chapter also describes the Oregon and Washington approaches to recovery implementation and the role of NMFS.

NMFS' vision[43] for recovery implementation is that the actions identified in salmon and steelhead recovery plans are carried out in a cooperative and collaborative manner and that recovery and delisting occur. NMFS' strategic goals to achieve that vision are to:

1. Sustain local support and momentum for recovery implementation.

2. Implement recovery plan actions within the time periods specified in each plan.

3. Ensure that the actions implemented contribute to achieving recovery.

4. Provide accurate assessments of species status and trends, limiting factors, and threats.

NMFS' strategic approach to achieving these goals is to:

- Support local efforts by using Domain Teams[44] to coordinate (internally and externally) and encourage recovery plan implementation.

- Use recovery plans to guide internal and external regulatory decision-making.

- Use non-regulatory authorities and encourage others to use their authorities to implement recovery plans.

- Provide leadership to regional forums to develop research, monitoring, and evaluation (RME) processes that track action effectiveness and status and trends at the population and DPS levels.

- Provide periodic reports on species status and trends, limiting factors, threats, and plan implementation status.

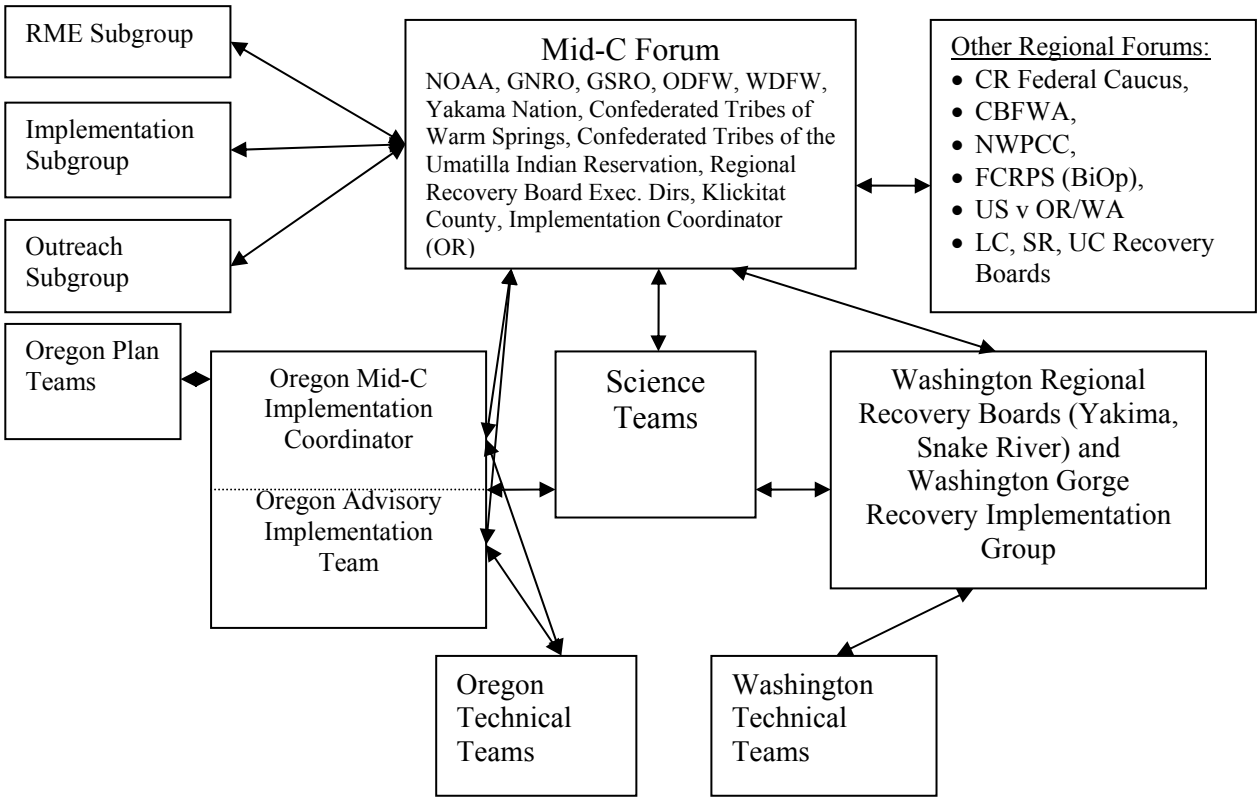
[42] The Mid-C Forum was formed in March, 2007 to assist NMFS in completing this recovery plan.
[43] From NMFS Northwest Region Memo dated February 26, 2008, subject: Northwest Region Recovery Implementation Strategy.
[44] Domain Teams are an organizational structure internal to NMFS whose purpose is to coordinate recovery plan completion and the recovery implementation effort. The teams promote consistency in internal decision making and work with state, tribal, and local recovery parties to achieve recovery plan objectives.

NMFS will carry out its vision, goals, and strategic approach to recovery for Middle Columbia steelhead by working in partnership with the Mid-C Forum.

11.1 Implementation Roles and Responsibilities

Effectively implementing recovery actions for Mid-C steelhead will require coordinating the actions of diverse private, local, state and Federal parties spread across two states. In Washington, regional recovery boards have taken the lead on coordinating recovery implementation within the Yakima and Snake management units[45]. In Oregon, an implementation coordinator and reformed advisory board will lead recovery plan implementation, supported by the governance structure for the Oregon Plan for Salmon and Watersheds. Actions in the Columbia River, its estuary, and the ocean are implemented by a broad range of partners, including NMFS, the Northwest Power and Conservation Council, the Bonneville Power Administration, the Bureau of Reclamation, the Army Corps of Engineers, Federal land management agencies, state and tribal fisheries co-managers, the Columbia River Estuary Partnership, and local parties and jurisdictions interested in salmon recovery. The Mid-C Forum will take the lead in efforts to coordinate the actions of these many players at a DPS-level, supported by both local and regional Science Teams. Figure 11-1 gives an overview of the relationships between these entities.

Figure 11-1. Mid-C Recovery Plan Implementation Organizational Structure.



[45] Implementation structures for the Eastern Cascades populations within Washington have yet to be determined.

11.1.1 Mid-C Forum

The Mid-C Forum provides organizational structure for communication and coordination on a bi-state and multi-tribal level across the entire DPS.

Specific functions include:

- Facilitating coordination and communication between Federal agencies, the Northwest Power and Conservation Council, states, tribes, management unit leads, and local recovery boards.
- Advocating for the recovery of Mid-C steelhead.
- Promoting the application of adaptive management in the DPS.
- Providing recommendations for resource prioritization.
- Networking with other multi-jurisdictional Columbia recovery planning groups (e.g. Lower Columbia, Upper Columbia, and Snake River) and Northwest Power and Conservation Council subbasin planning efforts.
- Providing a scientific interface with the Recovery Implementation Science Team (RIST).
- Coordinating and synthesizing RME efforts and activities.

The Forum will coordinate with broader efforts to develop common indicators for measuring trends. The Mid-C Forum may also identify legislative, congressional, and other funding opportunities for management actions and RM&E within the DPS. Policy issues will be resolved within respective local, state, Federal and tribal authorities and agencies.

Organization/Membership:
The Mid-C Forum is guided by a Steering Committee. NMFS will serve as the convening partner and provide facilitation, venues, and guidance. Steering Committee membership includes management unit leads (or their representative) in Washington and Oregon and representatives from the Oregon and Washington governors' offices, NMFS, Yakama Nation, Confederated Tribes of Warm Springs, Confederated Tribes of the Umatilla Indian Reservation, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, and Klickitat County.

There is no established membership for participation in the broader activities of the Forum. It is anticipated that participation in regular Forum meetings, as distinguished from meetings of the Steering committee, will vary depending on the topics and issues being addressed.

Operations:
The Mid-C Forum and Steering Committee will conduct regular meetings semi-annually, or as needed, and work to reach consensus on issues of dispute or discrepancy within the DPS.

Functional Topics:
The Forum will focus on four functional topics. For each topic the Forum may establish subgroups to organize, implement, and track progress. The decision to establish such subgroups will be determined based on the anticipated scope of work for each functional topic, Forum members' available staffing and funding, and other considerations as the Forum considers appropriate. The intent of these efforts is to support coordinated and effective implementation of the Mid-C Steelhead

Recovery Plan and to ensure that 5-year status reviews by NMFS are informed and efficient. The four functional topics are:

1. Research, Monitoring & Evaluation: RM&E will be coordinated by a Science Team which will be composed of RIST representatives, management unit technical representatives, ODFW/WDFW/tribal co-manager technical representatives, Klickitat County, etc. Focus areas may include:

    - Review/compile new information on VSP parameters and update stock status summaries accordingly.
    - Identify knowledge gaps that are high priorities across the DPS and review/coordinate efforts to address them.
    - Identify how to track threats criteria and provide annual summaries of applicable data.
    - Develop a DPS monitoring and evaluation and adaptive management plan.

2. Implementation: Subgroups may be composed of key project managers from management units, representatives from key funding programs (e.g., NMFS Restoration programs, Bonneville Power Administration, Columbia Basin Fish Accords[46], Northwest Power and Conservation Council, Oregon Watershed Enhancement Board, the Salmon Recovery Funding Board, and others), and key partners in recovery actions (such as USFS, BOR, and others). Their focus areas may include:

    - Review status of implementation scheduling for each management unit.
    - Share significant accomplishments by management units.
    - Promote technology transfer relevant to implementation across management units.
    - Communicate priorities for future actions to assist coordination across management units.
    - Identify opportunities where shared advocacy and coordination help implement key recovery actions (e.g., combine suitable proposals into single programmatic proposal; share technical resources for design review).

3. Outreach: Subgroups may be composed of representatives from state governors' staffs, co-manager policy leads, management unit representatives, and/or partner agency policy people. Their focus is to develop/support outreach related to Mid-C recovery, including reviewing/drafting NMFS two-year reports and updates to key decision makers (elected officials, agency heads, etc.).

[46] The Fish Accords consist of three Memorandums of Agreement (MOAs) entered into between the Federal Columbia River Power System (FCRPS) action agencies (Bonneville Power Administration, U.S. Army Corps of Engineers and the Bureau of Reclamation), four tribes, and one state. The most relevant MOA to the Middle Columbia River steelhead is with the Columbia River Inter-Tribal Fish Commission and the three treaty fishing tribes, Confederated Tribes of the Umatilla Indian Reservation; Confederated Tribes of the Warm Springs Reservation; and Confederated Tribes and Bands of the Yakama Nation. The MOAs are 10-year action agency commitments for projects to benefit fish affected by the FCRPS, with a focus on ESA-listed fish. The projects will be reviewed through the Northwest Power Act processes for implementing the Fish and Wildlife Program, administered by the Northwest Power and Conservation Council.

4. Policy: Policy issues will be managed by the Steering Committee, who may elect to organize subgroups for specific issues. Policy focus areas include:

    - Identify issues where joint advocacy supports Mid-C recovery action.
    - Track the status of Mid-C related activities in the Northwest Power and Conservation Council, Federal Caucus, FCRPS litigation, *U.S. v. Oregon*, *U.S. v. Washington*, and other regional forums.
    - Identify and, if appropriate, develop Mid-C policy proposals.

11.1.2 Management Unit Leads

The proposed organizational structure for plan implementation within Oregon and Washington is based on the structure used for development of the respective management unit recovery plans, with the note that these approaches differed, and will continue to differ, slightly. In Oregon, the Department of Fish and Wildlife (ODFW) led recovery plan development with assistance from the Governor's Natural Resources Office and NMFS. For implementation of the Oregon management unit recovery plan ODFW will seek an additional staff person (Implementation Coordinator) to facilitate implementation. In Washington, regional recovery boards, where they exist, developed the management unit plans and will coordinate plan implementation with guidance and support from the Governor's Salmon Recovery Office.

For the purposes of implementation, the term "management unit leads" (MU leads) refers to the Washington regional recovery boards, Oregon's recovery plan Implementation Coordinator (in conjunction with an Advisory Board) and, where no recovery board exists in Washington, NMFS. The MU leads have three primary responsibilities in regard to tributary-based implementation. Performance of these responsibilities will be influenced by MU lead capacity, authority, and MU priority, and will likely require other support structures or processes to fully accomplish these responsibilities. Not all of these duties can be accomplished initially with the current resources available. Prioritization of the initial duties will be guided by the statutory requirements of the ESA and the individual state's guidance.

The first responsibility for MU leads is to develop implementation schedules for the respective MUs, organized in a spreadsheet format consistent with NMFS interim recovery planning guidance (NMFS 2006). While all of the MU plans presently contain site-specific actions, priorities, and estimates of the time and cost sufficient to complete this DPS plan, further specificity will aid in local project selection and prioritization as well as in implementation reporting at the regional and national levels.

- Site-specific recovery actions specific to populations within the MUs.
- Limiting factor(s) addressed by each action.
- Priority for completing the action. Organize actions by priority level.
- Duration of and schedule for action, indicating also whether the action is new or already underway.
- Biological benefits of the action(s).
- Lead entity(ies) to implement each action.
- Estimated cost for each action over each of the next 5 years and a total cost for that action to recovery.

The second responsibility for MU leads is to coordinate implementation of recovery actions identified in the plan and implementation schedule. In this regard, they serve to facilitate two-way communication vertically (i.e., different spatial scales related to recovery plan governance) and horizontally (i.e., related programs, interests, and oversight outside of recovery plan governance). A key related program is the implementation of the Northwest Power and Conservation Council's Fish and Wildlife Program Subbasin Management Plans. The MU leads, in full coordination with the fishery agencies and tribes, should ensure that the project selection process for the Council's subbasin plans within the MU is consistent with implementing the ESA priority actions specified in this plan and the implementation schedules.

Specific responsibilities include:

- Coordinate with Federal and state agencies, Northwest Power and Conservation Council, tribes, local government, and other stakeholders, with an emphasis on implementing tributary habitat actions.

- Coordinate development of implementation strategies for voluntary actions requiring complex coordination among various entities, including:
    - local outreach
    - incentives
    - technical help
    - project funding
    - project management
    - monitoring/reporting

The third responsibility for MU leads is to track and report on progress of implementation in accordance with state and Federal reporting requirements. Specific responsibilities include:

- Coordinate plan monitoring within the MU.
    - Ensure appropriate tracking and reporting of recovery actions.

- Coordinate plan research within the MU.
    - Include results and reports in system information/outreach materials.

- Report on plan progress in relation to goals, strategies, and actions, using mechanisms and processes established for tracking progress.
    - Highlight plan successes and needs.

- Review and revise implementation schedules as necessary.
    - Use monitoring and research to guide actions.
    - Incorporate adaptive management, as needed.

- Represent the MU in the Mid-C Forum and Forum subgroups, as necessary.

11.1.3 Washington Regional Recovery Boards

Purpose and Function:
Regional Recovery Boards will be the MU Leads in Washington, and will serve those functions described under Section 11.1.2. In general, this entails overseeing, promoting, coordinating, and tracking actions and RM&E efforts within their respective management units (or within units that span two states) to ensure implementation of the Middle Columbia recovery plan. In addition, the Boards will coordinate data acquisition and sharing, seek funding opportunities for specific management unit actions, and track and ensure progress reporting to the Mid-C Forum on viability and threat trends for steelhead.

Regional Recovery Boards' regular operations are served by Executive Directors. The directors will coordinate Regional Recovery Board efforts, with assistance from the Governor's Salmon Recovery Office. Yakama Nation management and policy-level staff and other participants will coordinate with NMFS in areas not covered by a Recovery Board.

Organization/Membership:
Regional Recovery Boards include the Yakima Basin Fish and Wildlife Recovery Board and the Snake River Salmon Recovery Board. The Washington Gorge management unit will be served by the Yakama Nation, Klickitat County, and other participants NOAA brings into the recovery process. Where boards are in place, they are made up of government and tribal representatives and other local interests and are funded through the Washington Salmon Recovery Funding Board.

Operations:
Washington Regional Recovery Boards meet regularly, generally monthly or quarterly. Progress reporting will be done in coordination with existing "support" teams of Board and state/Federal/tribal agency staff.

The Yakima Basin and Snake River boards will report progress to the Mid-C Forum annually, including progress in management, conservation and RM&E actions, and trends in habitat health and salmonid viability.

Resources:
Washington's Recovery Boards will operate on existing funding sources.

11.1.4 Oregon Implementation Coordinator and Advisory Board

The Oregon Steelhead Recovery Plan proposes an updated implementation structure and approach in Section 12.1, Implementation and Adaptive Management. Figures 12.1 and 12.2 in the Oregon Steelhead Recovery Plan illustrate this new structure and working relationships to implement recovery actions and carry out adaptive management for the Oregon steelhead populations.

Implementation Coordinator: An ODFW implementation coordinator will serve as Oregon's "MU lead" for recovery plan implementation, under the advice and guidance of the Recovery Team. This individual will work with relevant teams, groups, entities and all relevant parties to implement the recovery plan. The Implementation Coordinator will work with the Implementation Team and Watershed Teams to plan, schedule, track and report on action implementation, and in coordination

with the Technical Team, develop, track and report on Adaptive Management activities (refer to Figure 12.1 in Oregon Steelhead Recovery Plan).

Recovery Team: The Recovery Team provides oversight and vision to recovery plan implementation. This team is responsible for reporting to NMFS and shares accountability for species recovery in the MU. The team provides overall coordination and guidance to the recovery plan teams, coordinates with other domain teams and the Oregon Plan Core Team, and serves as the state's representative at the bi-state Mid-C Forum. The Recovery Team is made up of representatives from the Governor's Natural Resource Office, the Oregon Department of Fish and Wildlife, Implementation Coordinator, Tribes, counties, and other major local entities.

Implementation Team: The Implementation Team provides advice, recommendations and support to the Implementation Coordinator. The Implementation Team is made up of Sounding Board members, watershed team representatives, NMFS, Tribes, Technical Team representative, and is chaired by the Implementation Coordinator.

Technical Team: The Technical Team provides advice and guidance on technical and science issues related to monitoring, research and evaluation, data analysis, and adaptive management that supports and strengthens effective implementation of the recovery plan. The Technical Team is made up of planning team representatives, other key Federal, state, local, tribal scientists, consultants, university professors and is chaired by a member of the Team or facilitator.

Watershed Teams: Watershed Teams are comprised of the various entities implementing local restoration and conservation actions via their respective organizations and entities. There will be a watershed team for each major watershed in the MU.

Figure 12.2 in the Oregon Steelhead Recovery Plan illustrates the relationships between these groups and how they will coordinate with each other. Oregon and NMFS will produce an implementation plan with a schedule to satisfy the requirements under the ESA.

11.1.5 NMFS

NMFS' role in Middle Columbia steelhead recovery is twofold. The first is to ensure that the agency's statutory responsibilities for recovery under the ESA are met. The second is to serve as the convening partner for the Mid-C Forum and to update forum members on issues relevant to recovery strategies. Forum meetings, for example, might contain standing agenda items where updates can be provided to the members on hatchery and harvest issues.

11.1.5.1 ESA Responsibilities

NMFS is responsible for the following tasks under the ESA:

- Ensure the recovery plan meets ESA statutory requirements, tribal trust and treaty obligations, and agency policy guidelines.
- Develop DPS-wide performance measures consistent with the recovery strategy outlined in Chapter 7.
- Conduct 5-year reviews (see Section 10.2).

- Make delisting determinations.
- Coordinate with other Federal agencies to ensure compliance under the ESA.
- Implement recovery plans.

11.1.5.2 Mid-C Convening Partner

As convening partner for the Mid-C Forum, the NMFS Northwest Regional Office, working through its Middle Columbia Recovery Coordinator and Domain Team, will:

- Convene Forum meetings on a regular basis (twice a year) and convene additional meetings as needed.
- Provide meeting facilitation services and manage the meeting process.
- Provide Forum meeting venues.
- Prepare and distribute meeting notes and follow up on tasks agreed to by the Forum.
- Serve as central clearinghouse for information, to include: DPS-wide stock status, relevant Federal scientific research, and DPS-wide gaps in recovery efforts.
- As requested by the Forum, establish and facilitate state, Federal and tribal meetings necessary for the coordination of recovery activities.

11.1.6 Technical Teams

Purpose and Function:
Technical teams are ad hoc work units or groups associated with supporting on-the-ground implementation of actions, monitoring and research, or technical analysis of data. The teams are a part of the foundation of implementation**.**

Organization/Membership:
Technical teams are composed of the members or staff of various watershed councils, soil and water conservation districts, non-governmental organizations, state agencies, Federal agencies, tribes, and others that conduct recovery plan actions, research, monitoring, or evaluation in the field or in the lab.

Operations:
Teams operate within their own internal structures, but will be requested to provide information and data to their respective MU Lead to ensure appropriate tracking and coordination within management units.

11.1.7 Science Team

Purpose and Function:
The Science Team will provide science input and advice to Mid-C actions, strategies, research designs, and RM&E priorities, including scoping science needs from RM&E needs at the MU and DPS-level. The Science Team will ensure that rigorous and "best available science" informs

implementation and is applied in RM&E for all "H's" within the DPS, and assist in translating information into status of species viability. The Science Team's input will be critical to 5-year reviews of the DPS.

Organization/Membership:
The Science Team will be a standing committee of the Forum and will be composed of RIST representatives, management unit technical representatives, ODFW/WDFW/tribal co-manager technical representatives, etc. The Science Team will select its own chair. It will coordinate with existing groups (e.g., the Recovery Implementation Science Team [RIST], Independent Science Advisory Board [ISAB], and/or the Independent Multidisciplinary Science Team [IMST]) or groups formed to provide scientific expertise for a specific purpose.

Operations:
The Science Team will operate on an ad hoc basis or on a regular schedule as determined by its members and will provide science oversight and guidance to the full DPS or to each management unit, as needed. The Science Team will coordinate with management unit technical teams where necessary.

11.2 Implementation Funding

Funding for project implementation is available from a variety of sources. The role of the Forum is to ensure MU plan implementers are aware of potential sources of funds and to advocate for the funding and implementation of actions that benefit all populations in the DPS. The Forum will not supersede decisions made by the individual management unit boards but may advocate for the funding of their projects and programs if requested.

Sources of implementation funding include:

- Pacific Coastal Salmon Recovery Fund (PCSRF) (States and tribes)
- Salmon Recovery Funding Board (SRFB) (Washington)
- Oregon Watershed Enhancement Board (OWEB) (Oregon)
- Columbia Basin Fish Accords
- Congressional appropriations (Federal agencies)
- State appropriations (State agencies)
- Northwest Power and Conservation Council Fish and Wildlife Program (States and tribes)
- Federal / state grants
- Non-profit organization programs and grants

11.3 Funding for Mid-C Forum Activities

Staff time for participation in the Mid-C Forum is to be funded by participating agencies and parties. NMFS will fund venues, facilitation, and other needs associated with convening Mid-C Forum meetings.

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Conservation and Recovery Plan
for Oregon Steelhead Populations in the
Middle Columbia River Steelhead Distinct Population Segment

February 2010

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ACKNOWLEDGMENTS

The Oregon Middle Columbia River Steelhead Recovery Plan represents three years of intense effort by many people from multiple disciplines. There are far too many contributors to acknowledge and thank individually; however, special recognition is deserved for the Oregon Mid-Columbia Steelhead Sounding Board who provided excellent guidance, input and support throughout the planning process. The Mid-Columbia Planning Team and Management Action teams were instrumental in providing a solid science foundation for the plan and sound future management actions that will contribute greatly to steelhead recovery in Oregon. The Mid-Columbia Expert Panel provided a valuable report on limiting factors and threats, a key element of the plan. Members of each of these groups are identified in Appendix A.

We thank Larry Lestelle who led the difficult and innovative effort to model the biological effectiveness of the management actions and Erin Gilbert for his masterful GIS mapping. This plan would never have come together without the efforts of Trish Bell. We thank Trish who contributed so much to logistics and coordination of the teams, and was instrumental in processing, compiling, and distributing the document.

Our hope is that this plan will serve as a roadmap and a vehicle to facilitate the continuation of the sound work already underway as well as accelerate improvement in habitat conditions and steelhead management. Successful plan implementation will lead to abundant, diverse, and productive steelhead populations that provide significant ecological, social, and cultural benefits.

CONTENTS

	Page
Acknowledgments	i
Contents	ii
Figures	viii
Tables	xix
Appendices List	xxxi
Acronyms and Abbreviations	xxxii
Section 1 Executive Summary	1-1
1.1 Background and Regional Context	1-2
1.2 A Cooperative Effort	1-4
1.3 Delisting the DPS	1-6
1.4 DPS Structure – A Hierarchical Steelhead Organization	1-8
1.5 Desired Status – Delisting and Broad Sense Recovery	1-11
1.6 Current Population Status	1-20
1.7 Gap Analysis	1-22
1.8 Limiting Factors and Threats	1-23
1.9 Recovery Strategies and Actions	1-28
1.10 Management Action Effectiveness	1-33
1.11 Time and Cost Estimates	1-37
1.12 Implementation Plan and Adaptive Management Framework	1-38
1.13 Research, Monitoring, and Evaluation	1-39
1.14 Population Summaries	1-42
Section 2 Introduction	2-1
2.1 Species Recovery under ESA	2-1
2.2 State of Oregon Recovery Planning	2-2
2.3 Tribal Treaty/Trust Obligations	2-4
Section 3 Background and Regional Context	3-1
3.1 Context of Plan Development	3-1
3.1.1 NMFS's Regional Process	3-1
3.1.2 State of Oregon Recovery Planning Process	3-3
3.2 Overview of Recovery Goals	3-4
3.3 Description and Taxonomy	3-8
3.4 Life History	3-11
3.5 Critical Habitat	3-12
Section 4 DPS Structure	4-1
4.1 Steelhead Population Structure: A Biologically-Based Hierarchy	4-1
4.1.1 Population Structure Adopted for Recovery Planning	4-2
Section 5 Desired Status—Delisting and Broad Sense Recovery	5-1
5.1 Delisting Goal and Criteria	5-1

CONTENTS (continued)

		Page
5.1.1	Overall Approach	5-1
5.1.2	Independent Population-level Viability Criteria	5-3
5.1.3	Major Population Group Viability Criteria	5-13
5.1.4	DPS Viability Criteria	5-17
5.2	Broad Sense Recovery Goal and Objectives	5-17
Section 6	Current Status—Viability Assessments	6-1
6.1	Fifteenmile Creek Winter Steelhead Population	6-1
6.2	Deschutes River Eastside Summer Steelhead Population	6-2
6.3	Deschutes River Westside Summer Steelhead Population	6-3
6.4	Lower Mainstem John Day River Summer Steelhead Population	6-5
6.5	North Fork John Day River Summer Steelhead Population	6-6
6.6	Middle Fork John Day River Summer Steelhead Population	6-7
6.7	South Fork John Day River Summer Steelhead Population	6-9
6.8	Upper Mainstem John Day River Summer Steelhead Population	6-10
6.9	Umatilla River Summer Steelhead Population	6-11
6.10	Walla Walla River Summer Steelhead Population	6-13
6.11	Major Population Groups Viability Assessments	6-14
6.12	DPS Viability Assessment	6-15
Section 7	Viability Gaps	7-1
7.1	Gaps Approach	7-1
7.2	Population Specific Viability Gaps	7-3
7.2.1	Fifteenmile Creek Population Gaps	7-3
7.2.2	Deschutes River Eastside Population Gaps	7-4
7.2.3	Deschutes River Westside Population Gaps	7-5
7.2.4	Lower Mainstem John Day River Population Gaps	7-5
7.2.5	North Fork John Day River Population Gaps	7-6
7.2.6	Middle Fork John Day River Population Gaps	7-6
7.2.7	South Fork John Day River Population Gaps	7-7
7.2.8	Upper Mainstem John Day River Population Gaps	7-7
7.2.9	Umatilla River Population Gaps	7-8
7.2.10	Walla Walla River Population Gaps	7-9
Section 8	Limiting Factors and Threats	8-1
8.1	Primary Limiting Factors and Threats Across and Within Populations	8-1
8.1.1	Primary Limiting Factors and Threats Across Populations	8-2
8.1.2	Primary Limiting Factors and Threats Within Populations	8-6
8.2	Tributary Habitat	8-17
8.2.1	Fifteenmile Creek Winter Steelhead, Tributary Habitat Limiting Factors	8-21
8.2.2	Deschutes River Eastside Population, Tributary Habitat Limiting Factors	8-25

CONTENTS (continued)

Page

8.2.3 Deschutes River Westside Population, Tributary Habitat Limiting Factors 8-31
8.2.4 Crooked River Population, Tributary Habitat Limiting Factors 8-36
8.2.5 Lower Mainstem John Day River Population, Tributary Habitat Limiting Factors 8-41
8.2.6 North Fork John Day River Population, Tributary Habitat Limiting Factors 8-46
8.2.7 Middle Fork John Day River Population, Tributary Habitat Limiting Factors 8-51
8.2.8 South Fork John Day River Population, Tributary Habitat Limiting Factors 8-56
8.2.9 Upper Mainstem John Day River Population, Tributary Habitat Limiting Factors 8-59
8.2.10 Umatilla River Population, Tributary Habitat Limiting Factors 8-63
8.2.11 Walla Walla River Population, Tributary Habitat Limiting Factors 8-73
8.3 Mainstem and Tributary Hydrosystems 8-78
8.3.1 Mainstem Hydropower Configurations and Operations 8-79
8.3.2 Tributary Hydropower Configurations and Operations 8-98
8.4 Estuarine and Plume Habitat 8-100
8.4.1 Changes in Plume Habitat 8-101
8.4.2 Predation 8-101
8.5 Harvest 8-102
8.5.1 Fisheries Management – Historically to Present 8-102
8.5.2 Allowed Harvest Impacts under NOAA Biological Opinions 8-105
8.5.3 Actual Recent Harvest Impacts 8-106
8.5.4 Tributary Fishery Impacts 8-111
8.6 Hatchery Practices and Releases 8-124
8.6.1 Overview 8-124
8.6.2 Fifteenmile Creek Steelhead 8-125
8.6.3 Deschutes River Steelhead 8-125
8.6.4 John Day River Steelhead 8-131
8.6.5 Umatilla River Steelhead 8-135
8.6.6 Walla Walla River Steelhead 8-143
8.7 Predation and Competition 8-145
8.7.1 Predation by Pinnipeds, Birds and Piscivorous Fish 8-146
8.7.2 Intra-Species Interactions 8-147
8.8 Climate Change 8-148
8.8.1 Steelhead Habitat Impacts 8-148
8.8.2 Potential Life Stage Specific Impacts 8-148
8.8.3 Potential Vulnerability Risk to Climate Change 8-151
Section 9 Recovery Strategies and Management Actions 9-1
9.1 Strategic Guidance for Management Actions 9-1
9.1.1 Prioritization Considerations 9-3

CONTENTS (continued)

Page

9.2 An Integrated Approach 9-4
9.2.1 Building on Current Efforts 9-7
9.3 Tributary Habitat Strategies and Actions 9-8
9.3.1 Habitat Strategies and Actions for Fifteenmile Creek Steelhead Population 9-12
9.3.2 Habitat Strategies and Actions for Deschutes River Eastside Steelhead Population 9-28
9.3.3 Habitat Strategies and Actions for Deschutes River Westside Steelhead Population 9-45
9.3.4 Habitat Strategies and Actions for Crooked River Steelhead Population ... 9-61
9.3.5 Habitat Strategies and Actions for Lower Mainstem John Day River Steelhead Population 9-78
9.3.6 Habitat Strategies and Actions for North Fork John Day River Steelhead Population 9-95
9.3.7 Habitat Strategies and Actions for Middle Fork John Day River Steelhead Population 9-111
9.3.8 Habitat Strategies and Actions for South Fork John Day River Steelhead Population 9-127
9.3.9 Habitat Strategies and Actions for Upper Mainstem John Day River Steelhead Population 9-142
9.3.10 Habitat Strategies and Actions for Umatilla River Steelhead Population ... 9-159
9.3.11 Habitat Strategies and Actions for Walla Walla River Steelhead Population 9-178
9.4 Hydrosystem Strategies and Actions 9-198
9.4.1 Mainstem Columbia River Hydropower Operations and Configurations 9-198
9.4.2 Tributary Hydropower Operations and Configurations 9-200
9.5 Estuarine and Plume Habitat Strategies and Actions 9-203
9.6 Harvest Strategies and Actions 9-204
9.6.1 Mainstem Harvest 9-204
9.6.2 Tributary Harvest 9-205
9.7 Hatchery Strategies and Actions 9-206
9.7.1 Overall Hatchery Strategy and Actions 9-206
9.7.2 Tributary Hatchery Strategies and Actions 9-207
9.8 Predation and Competition Strategies and Actions 9-219
9.8.1 Predation Strategies and Actions 9-219
9.8.2 Competition Strategies and Actions 9-221

Section 10 Management Action Effectiveness 10-1
10.1 Methods 10-1
10.1.1 Approach 10-1
10.1.2 Tributary Habitat Effectiveness 10-8
10.1.3 All-H Integration Across Life Cycle. 10-18
10.2 Analysis of Tributary Habitat Action Effectiveness.. 10-21

CONTENTS (continued)

Page

10.2.1 Fifteenmile Creek Winter Steelhead 10-22
10.2.2 Deschutes River Eastside Summer Steelhead 10-28
10.2.3 Deschutes River Westside Summer Steelhead 10-34
10.2.4 Lower Mainstem John Day River Summer Steelhead 10-41
10.2.5 North Fork John Day River Summer Steelhead 10-47
10.2.6 Middle Fork John Day River Summer Steelhead 10-53
10.2.7 South Fork John Day River Summer Steelhead 10-59
10.2.8 Upper Mainstem John Day River Summer Steelhead 10-65
10.2.9 Umatilla River Summer Steelhead 10-71
10.2.10 Walla Walla River Summer Steelhead 10-77
10.3 All-H Integration Analysis 10-83
10.3.1 Fifteenmile Creek Winter Steelhead, Projected Changes to Population Performance 10-84
10.3.2 Deschutes River Eastside Summer Steelhead, Projected Changes to Population Performance 10-87
10.3.3 Deschutes River Westside Summer Steelhead, Projected Changes to Population Performance 10-91
10.3.4 Lower Mainstem John Day River Summer Steelhead, Projected Changes to Population Performance 10-97
10.3.5 North Fork John Day River Summer Steelhead, Projected Changes to Population Performance. 10-100
10.3.6 Middle Fork John Day River Summer Steelhead, Projected Changes to Population Performance 10-103
10.3.7 South Fork John Day River Summer Steelhead, Projected Changes to Population Performance 10-106
10.3.8 Upper Mainstem John Day River Summer Steelhead, Projected Changes to Population Performance 10-109
10.3.9 Umatilla River Summer Steelhead, Projected Changes to Population Performance 10-112
10.3.10 Walla Walla River Summer Steelhead, Projected Changes to Population Performance 10-115
10.4 All-H Management Action Effectiveness Analyses for Spatial Structure/ Diversity 10-120

Section 11 Time and Cost Estimates 11-1
11.1 Cost Estimates 11-1
11.2 Time Estimates 11-5

Section 12 Implementation and Adaptive Management 12-1
12.1 Implementation 12-1
12.2 Adaptive Management 12-6
12.2.1 Tributary Habitat 12-7
12.2.2 Mainstem Hydrosystem 12-9
12.2.3 Harvest 12-11

CONTENTS (continued)

Page

12.2.4 Hatcheries 12-14
12.2.5 Implementation Progress and Status Check-ins 12-15

Section 13 Research, Monitoring, and Evaluation 13-1
13.1 Types of Monitoring Efforts 13-2
13.2 John Day River MPG 13-3
13.2.1 Lower Mainstem, North Fork, Middle Fork, South Fork, Upper Mainstem John Day Rivers Populations 13-5
13.3 Umatilla/Walla Walla Rivers MPG 13-14
13.3.1 Umatilla River Population 13-15
13.3.2 Walla Walla River Population 13-35
13.4 Cascades Eastern Slope Tributaries MPG 13-48
13.4.1 Fifteenmile Creek Population 13-49
13.4.2 Eastside and Westside Deschutes River Populations 13-56

Section 14 Literature Cited 14-1

FIGURES

Number		Page
1-1	The Middle Columbia River Steelhead DPS. Areas marked as extirpated Represent absence of only the anadromous form of *O. mykiss*	1-3
1-2	Oregon populations in the Mid-C Steelhead DPS.	1-4
1-3	Mid-C Steelhead DPS major population groups and independent populations.	1-9
1-4	Example of Abundance/Productivity viability curve	1-15
1-5	Matrix used to integrate Viable Salmonid Population parameter risk ratings and determine overall viability level.	1-17
3-1	NMFS Management Units for the Middle Columbia River Steelhead DPS.	3-2
3-2	Geographic boundaries of the Middle Columbia River Steelhead DPS.	3-9
3-3	Interior Columbia River Basin steelhead populations including populations in the Middle Columbia River Steelhead DPS (ICTRT 2003)	3-10
3-4	Critical habitat designated for salmon and steelhead in Oregon.	3-13
4-1	Hierarchical population structure within ESA-listed ESUs/DPSs, as identified by the TRTs.	4-2
4-2	Middle Columbia River Steelhead DPS major population groups and populations.	4-4
4-3	Major Population Groups and populations of the Middle Columbia River Steelhead DPS.	4-4
4-4	Independent populations within the Middle Columbia River Steelhead DPS.	4-5
5-1	Example of Abundance/Productivity viability curves including Fifteenmile Creek current abundance productivity point estimate with standard error elipse and adjusted standard error bounds.	5-10
5-2	Viable salmonid population spatial structure and diversity guidelines (McElhany et al. 2000). .	5-11
5-3	Assessing population viability across VSP criteria (ICTRT 2007).	5-13
5-4	MPG-level viability criteria identified by the ICTRT (ICTRT 2007).	5-14

FIGURES (continued)

Number		Page
5-5	DPS-level viability criteria identified by the ICTRT (ICTRT 2007).	5-17
6-1	Fifteenmile Creek Winter Steelhead population abundance and productivity compared to the DPS viability curve.	6-1
6-2	Deschutes River Eastside Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-2
6-3	Deschutes River Westside Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-4
6-4	Lower Mainstem John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-5
6-5	North Fork John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-6
6-6	Middle Fork John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-8
6-7	South Fork John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-9
6-8	Upper Mainstem John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-10
6-9	Umatilla River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-12
6-10	Walla Walla River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.	6-13
8-1	Areas within Oregon Mid-C steelhead populations that have significantly altered fire regimes and vegetative attributes that are altered from the historical condition (USFS condition class 3).	8-18
8-2	Geographic areas used in the EDT analysis for the Umatilla River Subbasin (NPCC 2004c).	8-71

FIGURES (continued)

Number		Page
8-3	Reach survival from McNary Dam to Bonneville Dam for PIT-tagged steelhead detected at McNary Dam between May 11 and June 8 for years 1999 to 2005 plotted with average spill percent at John Day, The Dalles and Bonneville dams.	8-87
8-4	Reach survival from McNary Dam to Bonneville Dam for Pit-tagged steelhead detected at McNary Dam between May 11 and June 8 for years 1999 to 2005 plotted with average water transit time for the reach McNary Dam to Bonneville Dam.	8-87
8-5	Reach survival from McNary Dam to Bonneville Dam for PIT-tagged steelhead detected at McNary Dam between May 11 and June 8 for years 1999 to 2005 plotted with average water temperature(C) measured at tailwater TDGS monitors for the reach McNary Dam to Bonneville Dam.	8-88
8-6	Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2001.	8-90
8-7	Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2002.	8-91
8-8	Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2003.	8-91
8-9	Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2004.	8-92
8-10	Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2005.	8-92
8-11	Average escapement for adult spring/summer Chinook salmon, fall Chinook salmon, and steelhead through the Federal Columbia River Power System, adjusted for known commercial and sport harvests	8-95
8-12	Number of steelhead harvested each year in Mainstem Columbia River fisheries (1866-1936) (Craig and Hacker 1940).	8-104
8-13	Commercial harvest rates on steelhead, 1938-2002 (WDFW and ODFW 2002). Non-tribal commercial harvest was discontinued in 1975.	8-104

FIGURES (continued)

Number		Page
8-14	Recreational harvest rates on steelhead in the mainstem below Bonneville Dam, 1964-2002 (WDFW and ODFW 2002). Blue is summer steelhead while pink is winter steelhead. All Mainstem fisheries became catch-and-release in 1992 and the impacts since that year were calculated by the encounter rate and an estimated release mortality.	8-105
8-15	Run timing at Bonneville Dam of steelhead and other species that are targeted in Mainstem commercial fisheries.	8-109
8-16	Number of steelhead released per number of Chinook landed by mesh size, as observed during monitoring and test fishing in 2003-2005 spring Chinook fisheries.	8-111
8-17	Relationship of Bonneville Dam wild Group A steelhead counts to estimated escapement above Nursery Bridge Dam, Oregon for run years 1993-1994 through 1996-2000.	8-123
8-18	Proportion of steelhead that are Round Butte Hatchery and out-of-subbasin hatchery origin by trapping facility: (a) Sherars Falls, (b) Pelton Trap, (c) WSNFH.	8-127
8-19	Migration timing of natural and hatchery summer steelhead smolts counted at Three Mile Falls Dam. The percentages were from weekly totals of fish divided by the respective total for the out-migration period. Daily Flow data at the lower Umatilla River gauge (RM 2.1) was averaged on a weekly interval (from Chess et al. 2003a).	8-141
8-20	Percent change in springtime water availability (March-May) from baseline conditions (1971-2000) to future conditions (2040s) and projected future relative risk to Mid-Columbia River steelhead (6^{th} field hydrologic units)	8-160
8-21	Modeled current summer (July 21-August 3) stream temperatures and growth zone characterization for Mid-Columbia River steelhead (6^{th} field hydrologic units)	8-161
8-22	Modeled future (2080) summer (July 21-August 3) stream temperatures and growth zone characterization for Mid-Columbia River steelhead (6^{th} field hydrologic units)	8-162

FIGURES (continued)

Number		Page
8-23	Projected future relative risk to Mid-Columbia River steelhead habitat (6th field hydrologic units) due to changes in summer (July 21-August 3) stream temperatures from current (2010) to future (2080) conditions	8-163
8-24	Precipitation coefficient of variation for the period (1971-2007) and relative risk for Mid-Columbia River steelhead (6th field hydrologic units)	8-164
8-25	Integrated climate change potential vulnerability risk for Mid-Columbia River steelhead (6th field hydrologic units)	8-165
9-1	Flow chart illustrating the process for development of tributary habitat strategies, actions, and programs and their characteristics	9-10
10-1	Use of EDT and AHA modeling platforms for different segments of steelhead life cycle. The EDT model covers the life stages from adults to subbasin through smolt emigration and AHA covers smolt passage through adult entry	10-3
10-2	Action integration components	10-6
10-3	Action effectiveness elements	10-13
10-4	Change in fitness in relation to proportion of strays used in AHA modeling	10-20
10-5	Estimated percent changes in population performance of Fifteenmile Creek winter steelhead due to tributary habitat actions	10-24
10-6	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Fifteenmile Creek winter steelhead	10-25
10-7	Map of the Fifteenmile Creek steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-26
10-8	Map of the Fifteenmile Creek steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-27

FIGURES (continued)

Number		Page
10-9	Estimated percent changes in population performance of Deschutes River Eastside summer steelhead due to tributary habitat actions	10-30
10-10	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Eastside summer steelhead	10-31
10-11	Map of the Deschutes River Eastside steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-32
10-12	Map of the Deschutes River Eastside steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-33
10-13	Estimated percent changes in population performance of Deschutes River Westside summer steelhead due to tributary habitat actions with and without passage at the Pelton-Round Butte Complex	10-37
10-14	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Westside summer steelhead	10-38
10-15	Map of the Deschutes River Westside steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-39
10-16	Map of the Deschutes River Westside steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-40
10-17	Estimated percent changes in population performance of Lower Mainstem John Day River summer steelhead due to tributary habitat actions	10-43

FIGURES (continued)

Number		Page
10-18	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Lower Mainstem John Day River summer steelhead	10-44
10-19	Map of the Lower Mainstem John Day River steelhead population showing Geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-45
10-20	Map of the Lower Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-46
10-21	Estimated percent changes in population performance of North Fork John Day River summer steelhead due to tributary habitat actions	10-49
10-22	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to North Fork John Day River summer steelhead	10-50
10-23	Map of the North Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-51
10-24	Map of the North Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-52
10-25	Estimated percent changes in population performance of Middle Fork John Day River summer steelhead due to tributary habitat actions	10-55
10-26	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Middle Fork John Day River summer steelhead	10-56

FIGURES (continued)

Number		Page
10-27	Map of the Middle Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-57
10-28	Map of the Middle Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-58
10-29	Estimated percent changes in population performance of South Fork John Day River summer steelhead due to tributary habitat actions	10-61
10-30	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to South Fork John Day River summer steelhead	10-62
10-31	Map of the South Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-63
10-32	Map of the South Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-64
10-33	Estimated percent changes in population performance of Upper Mainstem John Day River summer steelhead due to tributary habitat actions	10-67
10-34	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Upper Mainstem John Day River summer steelhead	10-68

FIGURES (continued)

Number		Page
10-35	Map of the Upper Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-69
10-36	Map of the Upper Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-70
10-37	Estimated percent changes in population performance of Umatilla River summer steelhead due to tributary habitat actions	10-73
10-38	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Umatilla River summer steelhead	10-74
10-39	Map of the Umatilla River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-75
10-40	Map of the Umatilla River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-76
10-41	Estimated percent changes in population performance of Walla Walla River summer steelhead due to tributary habitat actions	10-79
10-42	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Walla Walla River summer steelhead	10-80
10-43	Map of the Walla Walla River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches	10-81

FIGURES (continued)

Number		Page
10-44	Map of the Walla Walla River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions	10-82
10-45	Estimated population performance (productivity and equilibrium abundance) of Fifteenmile Creek winter steelhead associated with combinations of tributary and out-of-subbasin actions	10-86
10-46	Estimated population productivity of Deschutes River Eastside summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-89
10-47	Estimated population equilibrium abundance of Deschutes River Eastside summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-90
10-48	Estimated population productivity of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions and no passage at Pelton-Round Butte	10-94
10-49	Estimated population equilibrium abundance of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions and no passage at Pelton-Round Butte	10-95
10-50	Estimated population performance measures (productivity and equilibrium abundance) of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions and with passage at Pelton-Round Butte Complex	10-96
10-51	Estimated population performance measures (productivity and equilibrium abundance) of Lower Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-99
10-52	Estimated population performance measures (productivity and equilibrium abundance) of North Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-102
10-53	Estimated population performance measures (productivity and equilibrium abundance) of Middle Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-105

FIGURES (continued)

Number		Page
10-54	Estimated population performance measures (productivity and equilibrium abundance) of South Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-108
10-55	Estimated population performance measures (productivity and equilibrium abundance) of Upper Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-111
10-56	Estimated population performance measures (productivity and equilibrium abundance) of Umatilla River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-114
10-57	Estimated population performance measures (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-118
10-58	Estimated population performance measures (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of basin subbasin actions. Results are shown for actions performed on just Oregon lands and with actions combined on Oregon and Washington lands.	10-120
12-1	Implementation and adaptive management organizational chart for Oregon's Mid-C Steelhead Recovery Plan	12-4
12-2	Implementation and adaptive management organizational chart for the Mid-C DPS Steelhead Recovery Plan including the Oregon components	12-5
13-1	NMFS Listing Status Decision Framework.	13-2

TABLES

Number		Page
1-1	Population characteristics and minimum abundance and productivity (at the threshold abundance level) values that represent levels needed to achieve a 95% probability of persistence over 100 years for Oregon Mid-C steelhead populations.	1-15
1-2	Viability assessment results for Mid-C steelhead populations in the Cascades Eastern Slope Tributaries MPG.	1-21
1-3	Viability assessment results for Mid-C steelhead populations in the John Day River MPG.	1-21
1-4	Viability assessment results for Mid-C steelhead populations in the Umatilla/ Walla Walla Rivers MPG.	1-22
1-5	Integrated approach to address all factors limiting recovery of Oregon's Mid-C steelhead populations.	1-29
1-6	Summary of Recovery Information for Fifteenmile Creek Population.	1-43
1-7	Summary of Recovery Information for Deschutes River Eastside Population.	1-44
1-8	Summary of Recovery Information for Deschutes River Westside Population.	1-45
1-9	Summary of Recovery Information for Deschutes/Crooked River Population.	1-47
1-10	Summary of Recovery Information for Lower Mainstem John Day River Population.	1-48
1-11	Summary of Recovery Information for North Fork John Day River Population	1-50
1-12	Summary of Recovery Information for Middle Fork John Day River Population	1-52
1-13	Summary of Recovery Information for South Fork John Day River Population	1-53
1-14	Summary of Recovery Information for Upper Mainstem John Day River Population.	1-55
1-15	Summary of Recovery Information for Umatilla River Population.	1-56
1-16	Summary of Recovery Information for Walla Walla River Population.	1-58

TABLES (continued)

Number		Page
3-1	Types of sites and essential physical and biological features designated as PCEs, and the life stage each PCE supports.	3-13
5-1	Mid-Columbia River steelhead population viability curves in tabular format (return per spawner and population growth rate versions)[a]. (ICTRT 2007).	5-4
5-2	Habitat classes showing spawning potential by steelhead and Chinook.	5-6
5-3	Population characteristics and minimum abundance and productivity (at the threshold abundance level) values that represent levels needed to achieve a 95% probability of persistence over 100 years for Mid-Columbia steelhead populations in Oregon.	5-8
5-4	Organization of goals, mechanisms, factors and metrics for spatial structure and diversity risk rating (ICTRT 2007).	5-12
5-5	Characteristics of steelhead populations in Cascades Eastern Slope Tributaries MPG.	5-14
5-6	Characteristics of steelhead populations in the John Day River MPG.	5-15
5-7	Characteristics of steelhead populations in Umatilla/Walla Walla Rivers MPG.	5-16
6-1	Viability assessment results for Mid-C steelhead populations in the Cascades Eastern Slope Tributaries MPG.	6-14
6-2	Viability assessment results for Mid-C steelhead populations in the John Day River MPG.	6-15
6-3	Viability assessment results for Mid-C steelhead populations in the Umatilla/Walla Walla Rivers MPG.	6-15
7-1	Abundance/Productivity statistics, risk ratings, and observed and uncertainty gaps for Oregon Mid-C Steelhead populations.	7-4
8-1	Ranges of proportional reduction in survival for human-induced mortality factors that influence Oregon's Mid-Columbia River steelhead. Negative values are truncated to zero (Step 4 Report 2006).	8-5
8-2	Key and secondary threats to viability of the Fifteenmile Creek steelhead population (Mid-C Expert Panel 2006).	8-6

TABLES (continued)

Number		Page
8-3	Key and secondary threats to viability of the Deschutes River Eastside steelhead population (Mid-C Expert Panel 2006).	8-7
8-4	Key and secondary threats to viability of the Deschutes River Westside steelhead population (Mid-C Expert Panel 2006).	8-8
8-5	Key and secondary threats to viability of the extinct Deschutes Crooked River steelhead population (Mid-C Expert Panel 2006)	8-10
8-6	Key and secondary threats to viability of the Lower Mainstem John Day River steelhead population (Mid-C Expert Panel 2006).	8-11
8-7	Key and secondary threats to viability of the North Fork John Day River steelhead population (Mid-C Expert Panel 2006).	8-12
8-8	Key and secondary threats to viability of the Middle Fork John Day River steelhead population (Mid-C Expert Panel 2006).	8-13
8-9	Key and secondary threats to viability of the South Fork John Day River steelhead population (Mid-C Expert Panel 2006).	8-14
8-10	Key and secondary threats to viability of the Upper Mainstem John Day River steelhead population (Mid-C Expert Panel 2006).	8-15
8-11	Key and secondary threats to viability of the Umatilla River steelhead population (Mid-C Expert Panel 2006)	8-16
8-12	Key and secondary threats to viability of the Walla Walla River steelhead population (Mid-C Expert Panel 2006)	8-17
8-13	Limiting factors and priorities for protection and restoration as defined by EDT for Fifteenmile Creek Winter Steelhead (NPCC 2004a).	8-24
8-14	Habitat limiting factors summary for the Fifteenmile Creek steelhead population.	8-25
8-15	Limiting factors and priorities for protection and restoration as defined by EDT for Deschutes River Eastside steelhead population (NPCC 2004b).	8-28
8-16	Habitat limiting factors summary for the Deschutes River Eastside steelhead population.	8-30

TABLES (continued)

Number		Page
8-17	Limiting factors and priorities for protection and restoration as defined by EDT for Deschutes River Westside steelhead population (NPCC 2004b).	8-34
8-18	Habitat limiting factors summary for the Deschutes River Westside steelhead population.	8-35
8-19	Habitat limiting factors summary for the Crooked River steelhead population	8-40
8-20	Lower John Day watershed 303(d) listed stream segments and parameters of concern (ODEQ 2002 cited in NPCC 2005).	8-43
8-21	Limiting factors and priorities for protection and restoration as defined by EDT for the Lower Mainstem John Day River steelhead population (NPCC 2005).	8-44
8-22	Habitat limiting factors summary for the Lower Mainstem John Day River steelhead population.	8-45
8-23	North Fork John Day River subbasin 303(d) listed stream segments and water quality parameters of concern (ODEQ 2002 cited in NPCC 2005).	8-48
8-24	Limiting factors and priorities for protection and restoration as defined by EDT for North Fork John Day Steelhead (NPCC 2005).	8-48
8-25	Habitat limiting factors summary for the North Fork John Day River steelhead population.	8-50
8-26	Middle Fork John Day River subbasin 303(d) listed stream segments and parameters of concern in 1998 and 2002 (ODEQ 2002)	8-53
8-27	Limiting factors and priorities for protection and restoration as defined by EDT for Middle Fork John Day River steelhead.	8-54
8-28	Habitat limiting factors summary for the Middle Fork John Day River steelhead population.	8-55
8-29	Limiting factors and priorities for protection and restoration as defined by EDT for South Fork John Day River steelhead population.	8-58
8-30	Habitat limiting factors summary for the South Fork John Day River steelhead population.	8-59

TABLES (continued)

Number		Page
8-31	Upper John Day River watershed 303(d) listed stream segments and parameters of concern (ODEQ 2002).	8-61
8-32	Limiting factors and priorities for protection and restoration as defined by EDT for the Upper Mainstem John Day River steelhead population.	8-62
8-33	Habitat limiting factors summary for the Upper Mainstem John Day River steelhead population.	8-63
8-34	Impaired stream reaches from the 1998 303(d) list and used for development of the 2001 Umatilla Subbasin TMDL (ODEQ et al. 2001).	8-67
8-35	Barriers to upstream passage on streams in the Umatilla River Subbasin.	8-69
8-36	Limiting factors and priorities for protection and restoration as defined by EDT for Umatilla River summer steelhead population.	8-70
8-37	Habitat limiting factors summary for the Umatilla River steelhead population.	8-72
8-38	Barriers to Upstream Passage on Streams in the Walla Walla Subbasin within the Area Inhabited by the Walla Walla River steelhead population. This list is based on a combination of archived records and field observation.	8-75
8-39	Limiting factors and priorities for protection and restoration as defined by EDT for the Walla Walla River steelhead population.	8-77
8-40	Habitat limiting factors summary for the Walla Walla River steelhead population.	8-78
8-41	Smolt-to-adult return of Umatilla River wild summer steelhead at Three Mile Falls Dam for 1995-2002 migration years (White et al. 2007). Data are incomplete for 2001 and 2002 migration years.	8-83
8-42	Smolt-to-adult return (hatchery release to Three Mile Falls Dam) of Umatilla Hatchery steelhead 1987-97 broods (Rowan 1998; Chess et al. 2005).	8-83
8-43	Combined estimates of wild summer and winter steelhead subbasin smolt production, escapement to the mouth of the Hood River, and smolt-to-adult survival rate. Estimates are by year of migration. (Olsen 2005).	8-84

TABLES (continued)

Number		Page
8-44	Estimates of Foster and Hood River stock hatchery summer steelhead subbasin smolt production releases, adult escapements to the mouth of the Hood River, smolt-to-adult survival rate, and percent difference from the wild smolt-to-adult survival rate. Estimates are by year of migration. (Olsen 2005).	8-85
8-45	Estimates of Hood River stock hatchery winter steelhead subbasin smolt production releases, adult escapements to the mouth of the Hood River, smolt-to-adult survival rate, and percent difference from the wild smolt-to-adult survival rate. Estimates are by year of migration. (Olsen 2005).	8-86
8-46	Pearson correlation matrix for Snake River steelhead survival relationships.	8-88
8-47	Estimated survival from McNary Dam tailrace to Bonneville Dam tailrace for hatchery and wild steelhead (pooled) PIT tagged from the Snake River (from Williams et al. 2005).	8-89
8-48	SURPH generated survival and capture probabilities for natural summer steelhead tagged and released into the Umatilla River, 1999-2005 (White et al. 2007).	8-89
8-49	Estimated impacts (percent of run) on winter steelhead in winter and spring mainstem fisheries (2003-2005).	8-107
8-50	Estimated impacts (percent of run) on summer steelhead in summer and fall Zone 6 fisheries. Fish numbers include hatchery and wild steelhead, and impact rates are calculated based on the Bonneville Dam escapement.	8-108
8-51	Estimated size selectivity of the 2004 Zone 6 fishery. The size breakout is that "Small" fish are less than 78 cm, while "Large" fish are equal to or greater than 78 cm. Estimated impact rates are based on the abundance of each group at Bonneville Dam.	8-108
8-52	Characteristics of commercial fisheries in the Columbia River below Bonneville Dam.	8-110
8-53	Deschutes River expanded summer steelhead tribal harvest estimates for Sherars Falls, by run year (June 16-October 31). Harvest estimates are for the dip net and hook and line fisheries combined (ODFW/CTWSRO Creel Data).	8-115
8-54	Results of PVA simulations of estimated probability of extinction in 50 years for Umatilla steelhead under 16 different adult mortality rates.	8-120

TABLES (continued)

Number		Page
8-55	Number of steelhead by origin in the Deschutes River by year and trapping facility, 1977-2004.	8-128
8-56	Proportions of steelhead by origin in the Deschutes River by year and trapping facility, 1977-2004.	8-129
8-57	Proportion of hatchery-origin fish by location in the lower Deschutes Subbasin (for N > 9).	8-130
8-58	Year, run (W-winter, S-summer, U-unknown), number, tributary and subbasin of release for all known hatchery steelhead released into the John Day River Subbasin from 1925-1969.	8-130
8-59	Summary of all known stock records for hatchery salmonids released into the John Day River Subbasin from 1925-1997. Species include rainbow trout (RbT), steelhead of unknown run (Sthd), winter steelhead (StW), summer steelhead (StS), brook trout (BkT), and west slope cuttroat trout (WcT).	8-132
8-60	Hatchery source, stock, number recovered, recovery period, and release agency for hatchery steelhead with coded wire tags in the John Day River arm (Tumwater Falls upstream to Cottonwood Bridge) from 1996-2003. Data were compiled from the Pacific States Marine Fishery Commission Regional Mark Information System.	8-134
8-61	Hatchery source, release location, recovery location, number recovered, and recovery year for hatchery steelhead with coded wire tags in the John Day River above Cottonwood Bridge (RM 40) from 1988-2003.	8-134
8-62	Releases of summer steelhead in the Umatilla River Subbasin prior to the current program at Umatilla Fish Hatchery (Chess et al. 2003a).	8-137
8-63	Percent of Umatilla and non-endemic hatchery returns to Three Mile Falls Dam.	8-138
8-64	Percent of Umatilla and non-endemic hatchery returns available to spawn in nature	8-138
8-65	Adult summer steelhead collected at the fish trip on Birch Creek (T. Bailey, Oregon Department of Fish and Wildlife, personal communication, January 2001).	8-139

TABLES (continued)

Number		Page
8-66	Visual observations of natural and hatchery summer steelhead during spawning ground surveys (from Schwartz et al. 2005)	8-139
8-67	Release of LFH, Wallowa, Wells and Ringold stock steelhead smolts into the Walla Walla River, 1983-2005 release years.	8-144
8-68	Estimated numbers of adult hatchery- and natural-origin summer steelhead passing upstream of Nursery Bridge Dam from brood years 1993-2005.	8-145
8-69	Criteria for considering springtime water availability change ($\overline{SWAC}$), summer temperature change (STC), and historical precipitation variation (HPV) climate change risk metrics into an integrated potential climate change vulnerability index	8-157
9-1	Integrated approach to address threats and factors limiting recovery of Oregon's Mid-Columbia River steelhead populations	9-5
9-2	Umatilla Subbasin Geographic Areas	9-177
9-3	Restoration Priority Geographic Areas from the Walla Walla Subbasin Plan (NPCC 2004).	9-196
9-4	Protection Priority Geographic Areas from the Walla Walla Subbasin Plan (NPCC 2004).	9-196
9-5	Walla Walla Subbasin Geographic Areas.	9-196
9-6	Initial estimates of annual releases of summer steelhead to occur within specific areas of the drainage basin upstream of the Pelton-Round Butte Complex as the reintroduction effort moves forward.	9-213
10-1	Combinations of actions and effects modeled for each steelhead population using the AHA model	10-8
10-2	Tributary habitat actions modeled in each subbasin	10-10
10-3	Potential effectiveness levels assigned to actions	10-14
10-4	Intensity levels assigned to actions	10-15
10-5	Out-of-subbasin survival improvements for Mid-Columbia River steelhead populations	10-21

TABLES (continued)

Number		Page
10-6	Summary of tributary habitat action coverage and average action effectiveness values applied to the Fifteenmile Creek winter steelhead population	10-22
10-7	Estimated percent changes in population performance of Fifteenmile Creek winter steelhead due to tributary habitat actions	10-23
10-8	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Fifteenmile Creek winter steelhead	10-23
10-9	Summary of tributary habitat action coverage and average action effectiveness values applied to the Deschutes River Eastside summer steelhead population	10-28
10-10	Estimated percent changes in population performance of Deschutes River Eastside summer steelhead due to tributary habitat actions	10-29
10-11	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Eastside summer steelhead.	10-29
10-12	Summary of tributary habitat action coverage and average action effectiveness values applied to the Deschutes River Westside summer steelhead population	10-34
10-13	Estimated percent changes in population performance of Deschutes River Westside summer steelhead due to tributary habitat actions	10-35
10-14	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes Westside summer steelhead.	10-36
10-15	Summary of tributary habitat action coverage and average action effectiveness values applied to the Lower Mainstem John Day River summer steelhead population	10-41
10-16	Estimated percent changes in population performance of Lower Mainstem John Day River summer steelhead due to tributary habitat actions	10-42
10-17	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Lower Mainstem John Day River summer steelhead.	10-42

TABLES (continued)

Number		Page
10-18	Summary of tributary habitat action coverage and average action effectiveness values applied to the North Fork John Day River summer steelhead population	10-47
10-19	Estimated percent changes in population performance of North Fork John Day River summer steelhead due to tributary habitat actions	10-48
10-20	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to North Fork John Day River summer steelhead.	10-48
10-21	Summary of tributary habitat action coverage and average action effectiveness values applied to the Middle Fork John Day River summer steelhead population	10-53
10-22	Estimated percent changes in population performance of Middle Fork John Day River summer steelhead due to tributary habitat actions	10-54
10-23	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Middle Fork John Day River summer steelhead	10-54
10-24	Summary of tributary habitat action coverage and average action effectiveness values applied to the South Fork John Day River summer steelhead population	10-59
10-25	Estimated percent changes in population performance of South Fork John Day River summer steelhead due to tributary habitat actions	10-60
10-26	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to South Fork John Day River summer steelhead.	10-60
10-27	Summary of tributary habitat action coverage and average action effectiveness values applied to the Upper Mainstem John Day River summer steelhead population	10-65
10-28	Estimated percent changes in population performance of Upper Mainstem John Day River summer steelhead due to tributary habitat actions	10-66
10-29	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Upper Mainstem John Day River summer steelhead.	10-66

TABLES (continued)

Number		Page
10-30	Summary of tributary habitat action coverage and average action effectiveness values applied to the Umatilla River summer steelhead population	10-71
10-31	Estimated percent changes in population performance of Umatilla River summer steelhead due to tributary habitat actions	10-72
10-32	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Umatilla River summer steelhead.	10-72
10-33	Summary of tributary habitat action coverage and average action effectiveness values applied to the Walla Walla River summer steelhead population	10-77
10-34	Estimated percent changes in population performance of Walla Walla River summer steelhead due to tributary habitat actions	10-78
10-35	Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Walla Walla River summer steelhead.	10-78
10-36	Abbreviations used in tables reporting All-H integration results	10-83
10-37	Estimated population performance (productivity and equilibrium abundance) of Fifteenmile Creek winter steelhead associated with combinations of tributary and out-of-subbasin actions	10-85
10-38	Estimated population performance (productivity and equilibrium abundance) of Deschutes River Eastside summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-88
10-39	Estimated population performance (productivity and equilibrium abundance) of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-92
10-40	Estimated population performance (productivity and equilibrium abundance) of Lower Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-98
10-41	Estimated population performance (productivity and equilibrium abundance) of North Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-101

TABLES (continued)

Number		Page
10-42	Estimated population performance (productivity and equilibrium abundance) of Middle Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-104
10-43	Estimated population performance (productivity and equilibrium abundance) of South Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-107
10-44	Estimated population performance (productivity and equilibrium abundance) of Upper Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-110
10-45	Estimated population performance (productivity and equilibrium abundance) of Umatilla River summer steelhead associated with combinations of tributary and out-of-subbasin actions.	10-113
10-46	Estimated population performance (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of-subbasin actions	10-117
10-47	Estimated population performance (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of-subbasin actions. Results are shown for actions performed on just Oregon lands (P12Ore) and with actions combined on Oregon and Washington lands (P12OreWa)	10-119
11-1	Recovery Costs Summary Table	11-2

APPENDICES

APPENDIX A: Participants—Conservation and Recovery Plan for Oregon Steelhead Populations Middle Columbia River Steelhead Distinct Population Segment

APPENDIX B: Oregon Mid-Columbia Steelhead Viability Assessments

APPENDIX C: Summary of Habitat Projects Completed within Oregon's Mid-Columbia River Steelhead Populations on Private and Public Lands from 1995-2005 (Data provided by OWEB, USFS, BLM and Watershed Councils)

APPENDIX D: Hydropower Configuration and Operational Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations, and Estuary Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations

APPENDIX E: Forest Service and Bureau of Land Management Programs in Support of Mid-Columbia Steelhead Recovery Sufficiency Assessment

APPENDIX F: Habitat Programs Implemented by Oregon State Agencies to Address Limiting Factors and Threats to the Recovery of Listed Anadromous Salmon and Steelhead

APPENDIX G: Culverts that need to be improved or replaced

APPENDIX H: Management Actions Effectiveness Model Data and Assumptions

APPENDIX I: Cost Estimates for Recovery Actions

APPENDIX J: Fuels Treatment as an Action Contributing to Recovery of ESA-listed Anadromous Salmonids

ACRONYMS AND ABBREVIATIONS

AHA	All-H analyzer
A/P	Abundance/productivity
ACEC	Area of Critical Environmental Concern
AgWQM	Agricultural water quality management
BACI	Before-after-control-impact
BIA	Bureau of Indian Affairs
BiOp	Biological opinion
BLM	Bureau of Land Management
BMPs	Best management practices
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
cfs	Cubic feet per second
CAFO	Confined animal feeding operations
CBFWA	Columbia Basin Fish and Wildlife Authority
CCRP	Continuous Conservation Reserve Program
CDs	Conservation districts
CHART	Critical Habitat Assessment Review Team
CI	Confidence interval
CREP	Conservation Reserve Enhancement Program
CRFPO	Columbia River Fisheries Program Office
CRITFC	Columbia River Inter-tribal Fish Commission
CRP	Conservation Reserve Program
CSMEP	Collaborative Systemwide Monitoring and Evaluation Project
CSP	Conservation Security Program
CSS	Comparative survival study
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CTWSRO	Confederated Tribes of the Warms Springs Reservation of Oregon
CWA	Clean Water Act
CWT	**C**oded-wire tag
DART	Data access in real time
DBLT	Deschutes Basin Land Trust
DSL	Oregon Department of State Lands
DPS	Distinct population segment
DRC	Deschutes River Conservancy
EDT	Ecosystem Diagnosis and Treatment
EIS	Environmental impact statement
EMAP	Environmental monitoring and assessment protocol
EPA	Environmental Protection Agency
EQUIP	Environmental Quality Incentive Program
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FEIS	Final environmental impact statement
FERC	Federal Energy Regulatory Commission
FMEP	Fisheries Management and Evaluation Plan
FPC	Fish Passage Center
FPP	Fish per pound
FS	Forest Service
FSA	Farm Service Agency
FWC	Oregon Fish and Wildlife Commission
FY	Fiscal year
GFID	Gardena Farms Irrigation District #13
GM	Geometric mean
GMA	Growth Management Act
GRP	Grassland Reserve Program
HBDIC	Hudson Bay District Improvement Company
HFRP	Healthy Forest Reserve Program
HGMP	Hatchery and Genetics Management Plan
HID	Hermiston Irrigation District
HPV	Historical Precipitation Variation
HUC	Hydrologic unit code
ICTRT	Interior Columbia Technical Recovery Team
IFIM	Instream flow incremental methodology
IFP	Integrated fruit production
IHNV	Infectious Hematopoietic Necrosis Virus
IMW	Intensively monitored watershed

IRMP	Integrated Resource Management Plan
ISRP	Independent Scientific Review Panel
LBC	Lake Billy Chinook
LCREP	Lower Columbia River Estuary Partnership
LIDAR	Light detecting and ranging
LFH	Lyons Ferry Hatchery
LWD	Large woody debris
MaSA	Major spawning area
MiSA	Minor spawning area
MMPA	Marine Mammal Protection Act
MNF	Malheur National Forest
MOA	Memorandum of agreement
MPG	Major population group
MU	Management unit
NBD	Nursery Bridge Dam
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NFCP	Native Fish Conservation Policy
NGO	Non-government agency
NHD	National Hydrography Dataset
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration-Fisheries
NPMP	Northern Pikeminnow Management Program
NPCC	Northwest Power and Conservation Council
NRCS	Natural Resources Conservation Service
NTU	Nephelometric turbidity unit
NWFP	Northwest Forest Plan
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
ODEQ	Oregon Department of Environmental Quality
OHV	Off highway vehicle
OPSW	Oregon Plan for Salmon and Watersheds
ORV	Outstandingly remarkable values
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
PACFISH	Pacific Anadromous Fish Strategy
PCEs	Primary constituent elements
PCR	Polymerase chain reaction
PCSRF	Pacific Coastal Salmon Recovery Fund
PGE	Portland General Electric
PIT	Passive integrated transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
PRBC	Pelton-Round Butte Complex
PTAGIS	PIT Tag Information System
PVA	Population viability analysis
QAR	Quantitative analytical report
RBH	Round Butte Hatchery
RC&D	Resource conservation and development
RHCAs	Riparian habitat conservation areas
RIOG	Regional Implementation and Oversight Group
RM	River-mile
RMEF	Rocky Mountain Elk Foundation
RPA	Reasonable and prudent alternative
RSTs	Rotary screw traps
RSW	Removable spillway weir
SAR	Smolt-to-adult return
SEPA	State Environmental Policy Act
SID	Stanfield Irrigation District
SLEDs	Sea lion excluder devices
SMP	Shorelines Master Plan
SMU	Species Management Units
SNPs	Single nucleotide polymorphisms
SS/D	Spatial structure/diversity
SSB	Substitute Senate Bill
STC	Summer temperature change
SURPH	Survival under proportional hazards
SWAC	Springtime water availability change
SWCD	Soil and water conservation district
SWW	Selective water withdrawal
TDG	Total dissolved gas
TDGS	Total dissolved gas supersaturation

TIR	Thermal infrared
TMDL	Total maximum daily loads
TMFD	Three Mile Falls Dam
TNC	The Nature Conservancy
TRT	Technical Recovery Team
TSID	Three Sisters Irrigation District
TSS	Tri-State Steelheaders
UBWC	Umatilla Basin Watershed Council
UNF	Umatilla National Forest
UPA	Updated proposed action
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USFS	U.S.D.A. Forest Service
USFWS	U.S. Fish and Wildlife Service
UWCIG	University of Washington Climate Impact Group
VARs	Variances
VSP	Viable salmonid population
WAC	Washington administrative code
WCC	Washington Conservation Commission
WDOE	Washington Department of Ecology
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WEID	West Extension Irrigation District
WHP	Wellhead Protection Program
WHIP	Wildlife Habitat Incentive Program
WID	Westland Irrigation District
W/LC TRT	Willamette/Lower Columbia Technical Recovery Team
WSNFH	Warm Springs National Fish Hatchery
WRIA	Water Resources Inventory Area
WRP	Wetlands Reserve Program
WWBWC	Walla Walla Basin Watershed Council
WY	Water years
YN	Yakama Nation

Section 1 Executive Summary

This plan serves as a blueprint for the recovery of ten Middle Columbia River (Mid-C) steelhead populations that occupy Oregon tributaries to the Columbia River. The steelhead populations spawn and rear in the Fifteenmile Creek, Deschutes, John Day, Umatilla and Walla Walla river basins and are part of the Mid-C steelhead (*Oncorhynchus mykiss)* Distinct Population Segment (DPS). The DPS, which is listed as threatened under the Endangered Species Act (ESA), includes all steelhead populations in Oregon and Washington tributaries to the Columbia River upstream of the Hood and Wind river systems, up to and including the Yakima River.

The plan seeks to remove or minimize threats to the long-term persistence of Oregon's Mid-C steelhead populations and improve their viability to levels that will allow removal of the DPS from the threatened and endangered species list. The long-term goals, however, reach well beyond achieving DPS delisting. They aim to recover the populations and their habitats to levels that are not only viable, but also provide sustainable fisheries and other ecological, cultural, social and economic benefits for future generations.

Improving the status of Oregon's Mid-C steelhead populations is critical to DPS recovery. The populations play essential roles in achieving viability for three of four major population groups within the DPS. Status of most of the populations needs to improve to achieve viability criteria. The plan's recovery strategies and actions seek to remove threats to the long-term persistence of the populations and improve biological status so the populations meet viability requirements and support DPS recovery. Strategies and actions focus primarily on addressing threats to the populations posed by tributary habitat degradation, out-of-DPS hatchery strays, and hydrosystem development and operations — considered the main obstacles to recovery.

The plan provides information required by NOAA's National Marine Fisheries Service (NMFS) to satisfy the requirements of section 4(f) of the ESA and the State of Oregon's Conservation Plan requirements. It describes: 1) recovery goals and objective, measurable criteria which, when met, will result in a determination that the species be removed from the threatened and endangered species list; 2) site-specific management actions necessary to achieve the plan's goals; 3) estimates of the time required and cost to carry out the actions needed to achieve the plan's goals; and 4) direction for monitoring and evaluation and adaptive management to fine-tune our course towards recovery when needed.

The document contains:

- The institutional framework and rationale for recovery plans
- How NOAA's National Marine Fisheries Service expects to use the plan
- The regional context within which recovery plans in the Columbia Basin are written
- The relation of this plan to other planning processes and other ESA mandates
- Desired status—delisting and broad sense recovery goals; viability criteria
- The current status of listed Oregon Mid-C steelhead populations
- Gaps between current status and viable status
- Limiting factors and threats
- Recovery strategies and actions for the Oregon portion of the Mid-C steelhead DPS
- Management action effectiveness and expected outcomes
- Cost analysis
- A framework for implementation, monitoring and evaluation, and adaptive management

Still, the plan is not a regulatory document. The ESA does not require any agency or entity to implement the recovery strategies or specific actions in the recovery plan unless otherwise legally mandated (NMFS 2006a). It depends on the social and regulatory structure that currently exists for habitat, hydropower, harvest, hatchery and predation management and models the existing and expected changes for these important factors in the future. The plan identifies actions deemed necessary to achieve recovery goals, focusing on where changes can be accomplished that build upon and adapt from the existing social and regulatory programs. This approach acknowledges the policy choices that have been made in the past to maintain hydropower in the Columbia Region as well as other choices to sustain social and economic interests, while identifying actions necessary to reach recovery goals. If and when there are major changes in the underlying policy choices, this plan will need to be updated to clearly reflect these changes. While this plan identifies needed actions and priority locations, it also gives implementing agencies and citizens the flexibility to design creative, yet scientifically sound approaches that reflect site-specific conditions and support local interests.

This conservation and recovery plan will be considered a "living document." As new information becomes available, such as the outcome of the Federal Columbia River Power System Biological Opinion process, or as new information reveals the need for adaptive change, revised and additional actions will be added to the plan.

1.1 Background and Regional Context

Historically, Mid-C steelhead spawned and reared throughout central Oregon and south-central Washington. They occupied nine major Columbia River tributaries draining the east side of the Cascades Mountains, as well as numerous smaller systems. Major river systems include the White Salmon, Deschutes, John Day, Klickitat, Umatilla, Walla Walla, and Yakima rivers and Fifteenmile, Rock, and Willow creeks (Figure 1-1).

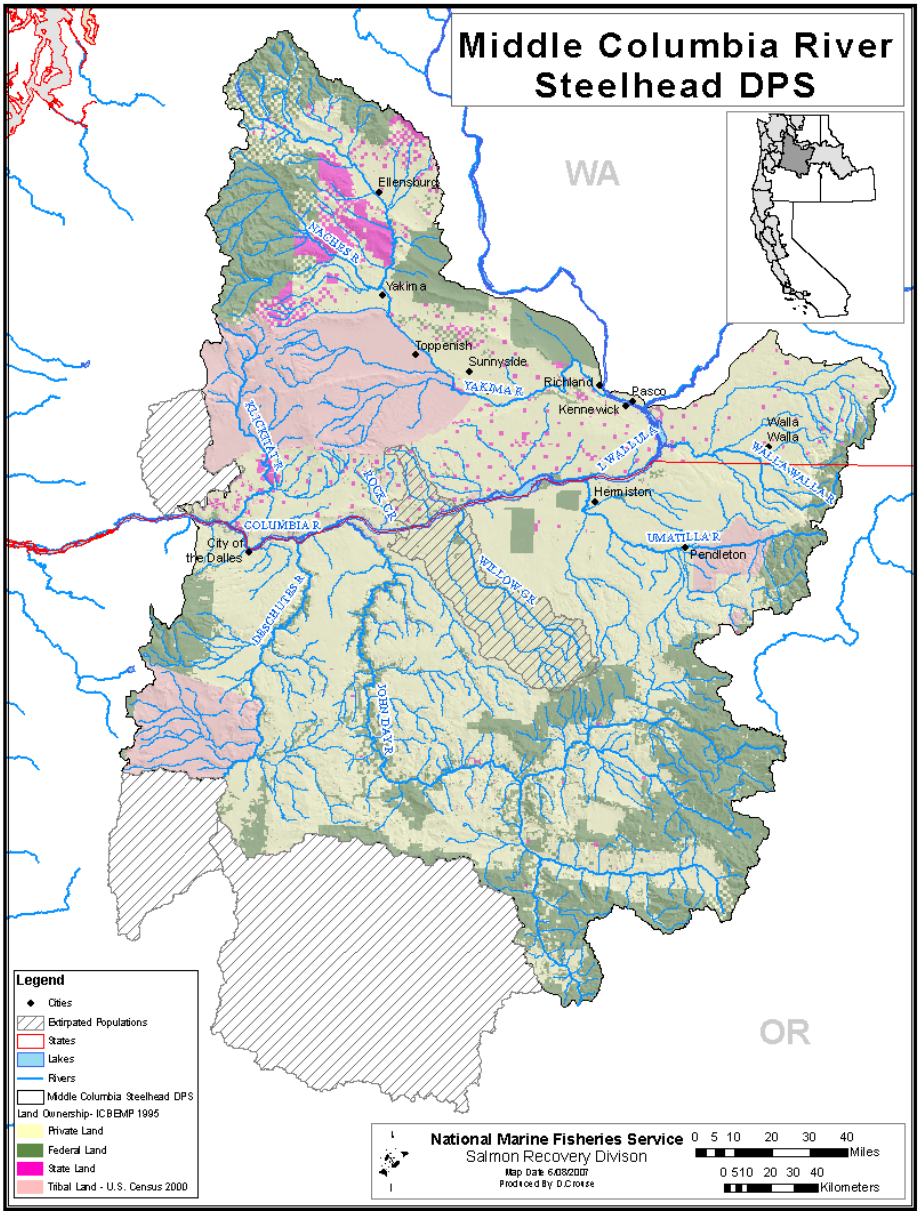


Figure 1-1. The Middle Columbia River Steelhead DPS. Areas marked as extirpated represent absence of only the anadromous form of *O. mykiss*.

By the late 1900s, Mid-C steelhead populations had experienced significant declines in abundance as a result of loss, damage or change to their natural environment. On March 25, 1999, NMFS listed Oregon's Mid-C steelhead populations as threatened under the Endangered Species Act as part of the Middle Columbia River steelhead Evolutionarily Significant Unit (ESU) (69 FR 33101). The ESU included both anadromous and resident forms of the biological species *Oncorhynchus mykiss (O.mykiss).* Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS). NMFS listed the Middle Columbia River steelhead DPS as threatened on January 5, 2006 (71 FR 834). The DPS consists of all historical steelhead populations in Oregon and Washington tributaries of the Columbia River upstream of the Hood

and Wind river systems, up to and including the Yakima River. It is one of 17 ESUs and DPSs of salmon and steelhead in the Pacific Northwest listed under the ESA.

The populations remain highly valued by Native Americans and many other people in the Pacific Northwest. The steelhead populations have long had important tribal subsistence, ceremonial and commercial values for Native Americans, including the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Confederated Tribes of the Warm Springs Reservation of Oregon. Native Americans continue to maintain strong cultural values for steelhead and salmon species. Northwest Indian tribes hold legally enforceable treaty rights reserving to them a share of the salmon harvest. Local communities and others in the region also treasure the steelhead populations and their habitats as important resources, and want to see them rebuilt to sustainable, harvestable levels. All of these rights and expectations will not necessarily be fully met by achieving only the basic purpose of the ESA and delisting of the species, although it will lead to major improvements in the current situation. The recovery plan's broad sense goals and objectives address these and other issues.

1.2 A Cooperative Effort

This conservation and recovery plan is one piece of a larger, integrated recovery plan for the entire DPS. It addresses factors limiting the viability of Mid-C steelhead populations within the State of Oregon (Figure 1-2). The DPS-level recovery plan also includes individual recovery plans for the other areas in the DPS.

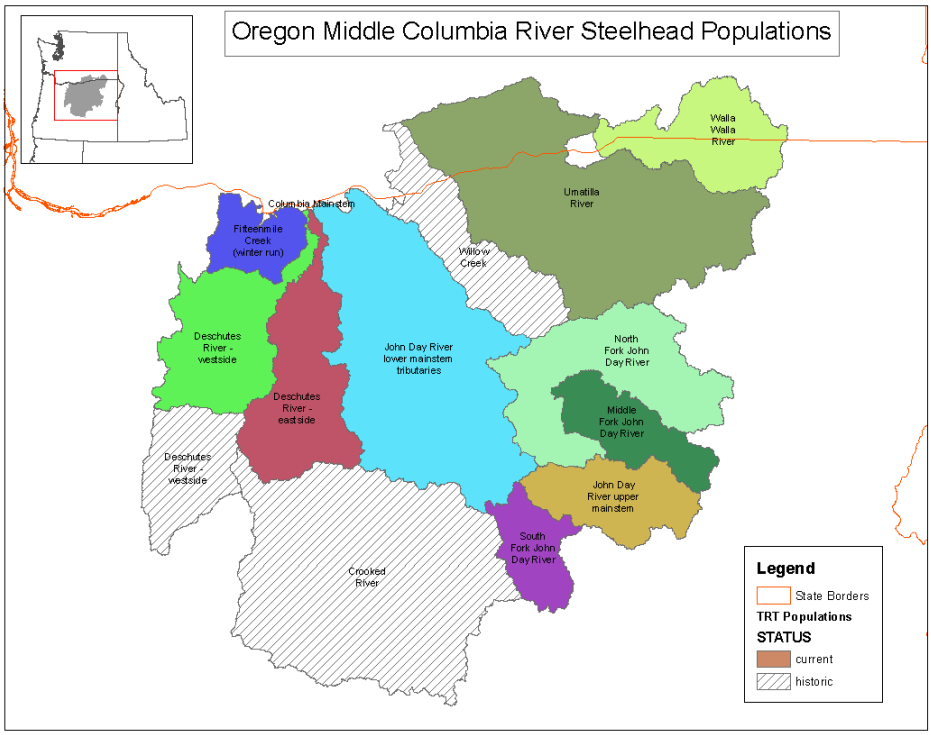


Figure 1-2. Oregon populations in the Mid-C Steelhead DPS.

State of Oregon Recovery Planning

The State of Oregon led the development of this recovery plan for Oregon Mid-C steelhead in partnership with NMFS, other natural resource agencies, the tribes, and local communities. The State's approach to recovery planning is grounded in an understanding that the challenges of steelhead recovery are immense—particularly in the face of growing human populations and demands for clean water and other precious resources. The recovery plan was developed to parallel and build from the Oregon Plan and the Oregon Conservation Strategy.

The Oregon Department of Fish and Wildlife facilitated the plan's development through a collaborative process with broad technical, stakeholder and public involvement. We have involved critical players at each stage in the decision-making process. Oregon's recovery planning forums include the Middle Columbia Sounding Board, the Mid-Columbia Recovery Planning Team, and Management Action Teams. We are relying heavily on these different players to make sure that our recovery strategy for Oregon Mid-C steelhead in scientifically sound and defendable. This involvement is vital for the plan's successful implementation.

- *Middle Columbia Sounding Board (MCSB).* The MCSB consists of representatives of local communities, agricultural and timber interests, land managers, governing bodies, tribes, and industry and environmental interests. The MCSB provides policy guidance in the development of all aspects of the plan and ensures selection of locally appropriate and locally supported recovery actions needed to achieve species recovery goals. The MCSB was particularly instrumental in the development of broad sense recovery goals, recovery scenarios, recovery strategies, strategic guidance for development and prioritization of management actions, and implementation planning.

- *Mid-Columbia Recovery Planning Team.* The recovery planning team includes state, Federal, Tribal, and watershed council technical representatives across the DPS. The team provided technical guidance and writing for all aspects of the plan.

- *Management Action Teams.* The three management action teams include local experts representing state and federal natural resource agencies, the tribes, watershed councils and Portland General Electric. The teams developed management actions for the ten steelhead populations.

Oregon recovery planners also incorporated findings from groups with broader areas of responsibility than the Mid-Columbia, including the Interior Columbia Technical Recovery Team and the Oregon Expert Panel.

- *Interior Columbia Technical Recovery Team (ICTRT).* The ICTRT, appointed by NMFS, provides geographic and species expertise for the entire Interior Columbia domain. The team includes biologists from NMFS, state, tribal and local entities, academic institutions, and private consulting firms. The ICTRT plays an important role in recovery planning, including developing ESU/DPS and population viability criteria that will be used, along with threats-based criteria, to determine whether a species has recovered sufficiently to be downlisted to threatened (if endangered) or delisted.

- *Oregon Expert Panel.* The Expert Panel was created by the Oregon Department of Fish and Wildlife for purposes of recovery planning and consisted of biologists with significant knowledge of the limiting factors and threats influencing Oregon's listed salmon and steelhead populations. Panelists identified common key and secondary threat themes for the populations.

Involvement by these different entities helps ensure that recovery goals and actions are consistent and compatible with the goals and direction adopted in related efforts. This integrated approach establishes partnerships that allow actions to be implemented effectively and efficiently.

1.3 Delisting the DPS

The overarching aim of this recovery plan is removal of the Middle Columbia River steelhead DPS from the threatened and endangered species list. Section 4(a) (1) of the ESA and NMFS implementing regulations (50 CFR part 424) establish procedures for listing species. According to this direction, the Secretary of Commerce must determine if a species is endangered or threatened because of any one or a combination of the following factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or human-made factors affecting its continued existence.

Listing Factors

In its initial determination to list the species, NMFS found (1996, 1997) that all five listing factors had played a role in the decline of the West Coast salmon and steelhead ESUs. These factors may or may not still be limiting recovery in the future when NMFS reevaluates the status of the species to determine whether the protections of the ESA are no longer warranted and the species may be "delisted." Findings leading to the listing of West Coast salmon and steelhead, including Mid-C steelhead, include:

1. *The present or threatened destruction, modification, or curtailment of its habitat or range*. Salmon and steelhead have experienced declines in abundance over the past several decades as a result of loss, damage or change to their natural environment. Water diversions, forestry, agriculture, mining, and urbanization have eliminated, degraded, simplified, and fragmented habitat. Hydroelectric development on the mainstem Columbia River modified natural flow regimes and impaired fish passage. Tributary obstructions also restrict or block salmon and steelhead access to historical habitats.

2. *Overutilization for commercial, recreational, scientific, or educational purposes.* Overfishing in the early days of European settlement led to the depletion of many salmonid stocks before extensive modifications and degradation of natural habitats, and exploitation rates following the degradation of many aquatic and riparian ecosystems were higher than many populations could sustain. Today, steelhead harvest continues on

the Columbia River, tributaries and Pacific Ocean; however, fishery impacts have declined significantly because of changes in fishery management.

3. *Disease or predation.* Introductions of non-native species and habitat modifications have resulted in increased predator populations in numerous rivers. Predators on adult and juvenile steelhead include seabirds, such as Caspian terns, walleye and California sea lions.

4. *Inadequacy of existing regulatory mechanisms.* Various federal, state, county and tribal regulatory mechanisms are in place to reduce habitat loss and degradation caused by human use and development. Many of these mechanisms have been improved over the years to slow the habitat degradation and destruction. Protective efforts directed toward addressing the many factors that adversely impact Mid-C steelhead and habitat—water quality and quantity, safe migration, riparian vegetation, food, predation dynamics and complex stream channels, and floodplain connectivity—will aid in improving these factors.

5. *Other natural or human-made factors affecting its continued existence*. Variability in ocean and freshwater conditions can have profound impacts on the productivity of salmonid populations and, at different times, have exacerbated or mitigated the problems associated with degraded and altered riverine and estuarine habitats.

NMFS listed the Middle Columbia River ESU in response to a biological review that concluded that summer steelhead in the ESU were "likely to become endangered in the foreseeable future" (NMFS 1999). Prominent features leading NMFS to list the ESU included: (1) declines in abundance of wild steelhead populations, (2) levels of abundance well below historical levels, (3) large numbers of hatchery-origin steelhead entering the Deschutes River basin, and a lack of information regarding this phenomenon, (4) large numbers of hatchery steelhead relative to wild steelhead and a general lack of information regarding the impacts of hatchery steelhead on wild steelhead populations throughout the region, (5) a lack of information regarding the interactions between resident rainbow trout and anadromous steelhead, and (6) habitat alterations in the region resulting in a loss of spawning and rearing habitat for steelhead, including habitat changes that have exterminated some steelhead runs (Busby et al. 1996; NMFS 1999).

Critical Habitat

NMFS designated critical habitat for Mid-C steelhead and 12 other ESUs of salmon and steelhead in a final rule that took effect on January 2, 2006. Essential features of designated critical habitat include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water, velocity, space, and safe passage. The Critical Habitat Assessment Review Team (CHART) has rated the conservation value of all 5th-field HUCs supporting populations of Mid-C steelhead. Section 3 of the draft recovery plan discusses the physical and biological primary constituent elements (PCEs) identified as essential to the conservation of the species and shows streams designated critical habitat for Mid-C steelhead.

1.4 DPS Structure — A Hierarchical Steelhead Organization

Our approach to recovery recognizes that a hierarchical steelhead organization structure exists in the DPS. This hierarchical structure extends from the DPS level to a level below the independent population, with individual steelhead in the DPS often sharing more genetic and life history similarities with their closest neighbors than with steelhead from other parts of the DPS. The homing propensity, distribution across the landscape, and the diverse genetic, life history and morphological characteristics that evolve contribute significantly to this hierarchical structure and the species long-term persistence.

The ICTRT has identified three levels in this hierarchy that reflect genetic, geographic (hydrographic) and habitat considerations in the DPS (ICTRT 2003). The State of Oregon adopted this biological hierarchy for purposes of Mid-C steelhead recovery planning.

- *Evolutionarily Significant Units and Distinct Population Segments* listed under the ESA must be substantially reproductively isolated from other nonspecific units, and represent an important component of the evolutionary legacy of the species (Waples 1991).

- *Major Population Groups (MPGs)* are independent populations in an ESU or DPS that share similar genetic, geographic (hydrographic and ecoregion), and/or habitat characteristics (ICTRT 2003). The ICTRT defined a grouping as a Major Population Group (MPG), which is analogous to "strata" as defined by the Lower Columbia-Upper Willamette TRT and "geographic region" described by the Puget Sound TRT.

- *Independent Population* as defined by McElhany et al. (2000) is "a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."

The ICTRT divided the Mid-Columbia steelhead DPS into four major population groups: Cascades Eastern Slope Tributaries MPG, Yakima River MPG, John Day River MPG and Umatilla/Walla Walla Rivers MPG (Figure 1-3). Three of these MPGs contain Mid-C steelhead from Oregon tributaries.

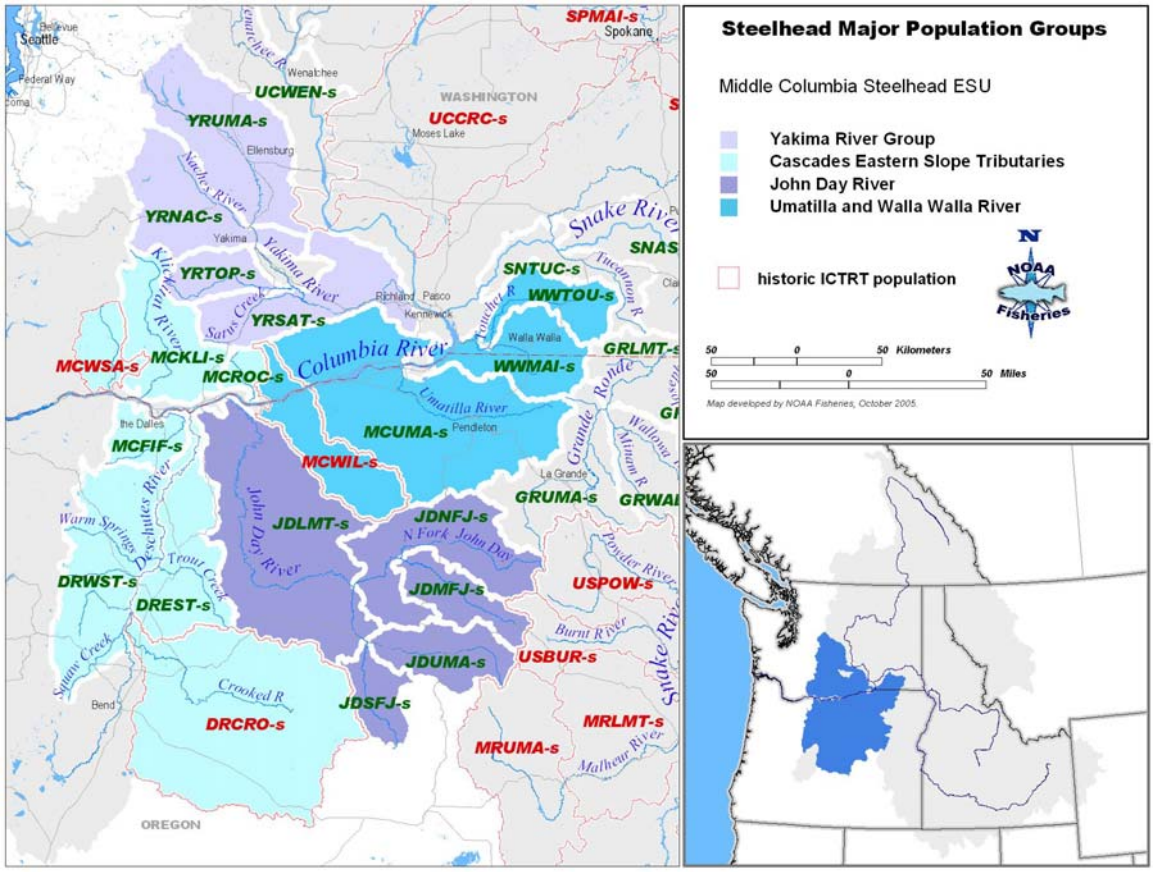


Figure 1-3. Mid-C Steelhead DPS major population groups and independent populations.

Major Population Groups and Oregon Populations

The three MPGs that support Oregon Mid-C steelhead, and the Oregon populations within them, are the focus of this recovery plan and are discussed below. Independent populations are the units that will be combined to form alternative recovery scenarios for MPG and DPS viability.

Cascades Eastern Slope Tributaries MPG

The Cascades Eastern Slope Tributaries MPG contains five extant populations (Fifteenmile Creek, Deschutes River Westside, Deschutes River Eastside, Klickitat and Rock Creek) and two extinct populations (White Salmon and Crooked River). Populations in this MPG are united primarily by geographic proximity. The Columbia River tributaries that support them generally drain the eastern slope of the Cascades and the dry Columbia Plateau, and display varied habitat conditions. The MPG supports summer and winter run life history forms of steelhead. It contains three extant and one extinct Oregon populations:

1. The *Fifteenmile Creek* population occupies Fifteenmile Creek and its tributaries, Fivemile, Eightmile and Ramsey creeks. It also includes five drainages outside of the Fifteenmile Creek watershed, Threemile, Mill, Chenoweth, Mosier, and Rock creeks, that flow directly into the Columbia River. Fifteenmile Creek steelhead are exclusively

winter run fish and are considered the easternmost distribution of winter steelhead in the Columbia basin.

2. The *Deschutes River Eastside* population encompasses the mainstem Deschutes River from its mouth to the confluence of Trout Creek and the tributaries entering the Deschutes from the east, including Buck Hollow, Bakeoven, and Trout creeks. Steelhead in this population are exclusively summer run fish.

3. The *Deschutes River Westside* population covers the mainstem Deschutes River upstream from the mouth of Trout Creek and tributaries entering the Deschutes from the west. Current steelhead access extends from Trout Creek to the Pelton Re-regulating Dam on the mainstem Deschutes and into the Warm Springs River, Shitike Creek and several smaller tributaries. Pelton Dam, a hydroelectric dam at RM 100 on the Deschutes River, blocks all anadromous fish passage to historical habitat above the dam, including areas in the Metolius River and Whychus Creek. The population is a summer run. It is separated from the eastside tributary population based on habitat and life history characteristics.

4. The *Deschutes Crooked River* population once occupied the Crooked River drainage, a major watershed in the Deschutes basin. The population is now extinct because of the lack of passage above Pelton Dam. A current management agreement and plan aim to re-establish steelhead production within the population's boundaries.

John Day River MPG

The John Day River MPG covers Oregon's John Day River drainage. The MPG contains five extant populations (Lower Mainstem John Day, North Fork John Day, Middle Fork John Day, South Fork John Day and Upper Mainstem John Day). Steelhead in these populations are exclusively summer steelhead. The MPG is one of the few remaining summer steelhead groups in the Interior Columbia basin that has had no intentional influence from introduced hatchery steelhead and that has recently been classified as strong or healthy (Lee et al. 1997; Huntington et al. 1994). Spawning is widely distributed across tributary and mainstem habitats.

1. The *Lower Mainstem John Day River* population includes tributaries to the John Day River downstream of the South Fork John Day River. This widespread population is the most differentiated ecologically from other populations, occupying the lower, drier, Columbia Plateau ecoregion.

2. The *North Fork John Day River* population occupies the highest elevation, wettest area in the John Day basin. Population boundaries include the main stem and tributaries of the North Fork John Day River. The population was defined based on habitat characteristics, basin topography, and demographic patterns.

3. The *Middle Fork John Day River* population resides in the Middle Fork John Day and all its tributaries. Spawning areas in the Middle Fork John Day River are separated substantially from all other spawning areas; except for those in the North Fork John Day, that exhibit different habitat characteristics.

4. The *South Fork John Day River* population occupies the South Fork John Day River drainage. The independent population was defined based on genetic information and basin topography.

5. The *Upper Mainstem John Day River* population includes the mainstem John Day River and tributaries upstream from the South Fork. It is separated from the lower mainstem based on habitat differences and from the South Fork because of topography.

Umatilla/Walla Walla Rivers MPG
This major group includes three extant populations (Umatilla River, Walla Walla River and the Touchet River, a tributary of the Walla Walla River in Washington State) and one extinct population (Willow Creek). The Umatilla and Walla Walla rivers drain the northwestern slopes of the Blue Mountains, with lower reaches in the warmer, drier habitats of the Columbia Plateau. Genetic information, distance between spawning aggregates and ecoregional classifications contributed to ICTRT population delineations within this major group. The entire Umatilla drainage and part of the Walla Walla lie within the State of Oregon's borders and are addressed in this plan.

1. The *Umatilla River* population spawns and rears in the Umatilla watershed and several small tributaries to the Columbia River in eastern Washington State. The population is separated from the Walla Walla River based on genetic analysis and distance.

2. The *Walla Walla River* population occupies much of the Walla Walla drainage. One major tributary to the Walla Walla River, the Touchet River, is considered a separate population based on genetic analyses.

3. The *Willow Creek* population is extinct. It was designated as an independent population based on geographic distance from other populations and capacity sufficient to support an independent population.

1.5 Desired Status — Delisting and Broad Sense Recovery

The desired status for Oregon's Mid-C steelhead populations is two-tiered. First, the populations must reach desired levels of biological viability to support removal of the DPS from the threatened and endangered species list. Second, the State of Oregon and the Middle Columbia Sounding Board seek to rebuild the populations to provide for sustainable fisheries and other ecological, cultural, social and economic benefits. The recovery goals, viability criteria and potential recovery scenarios described in the plan are summarized below.

Delisting Goal

Our primary goal is to support removal of the Mid-C steelhead DPS from the threatened and endangered species list. This requires that the populations must reach the levels of biological viability defined by the ICTRT and adopted by the State of Oregon in this plan as delisting criteria. In the context of recovery, delisting criteria and viability criteria are considered

synonymous. Achieving ICTRT biological viability status at the population and MPG levels is needed before the DPS can be considered at low risk of extinction and a candidate for delisting.

To attain viability at the MPG level, the populations included in the viable MPG-level scenarios must be at or above viable status as defined by the ICTRT's viability criteria (ICTRT 2006). In addition, the criteria require that other extant populations within a MPG must be maintained at sufficient levels to provide for ecological functions and to preserve options for DPS recovery so that overall MPG productivity does not fall below replacement. Further, this plan recommends a staged, adaptive approach to recovery planning and implementation. Such an approach gives highest priory initially to implementing actions within currently occupied areas and, thus, to improving the status of extant populations and MPGs.

Broad Sense Recovery Goal

After achieving steelhead recovery under the ESA, the State of Oregon aims to rebuild Oregon's Mid-C steelhead populations to levels that will provide for sustainable fisheries and other ecological, cultural and social benefits consistent with achievement of the goals of the Oregon Plan for Salmon and Watersheds. Although broader than the definition of delisting provided by the ESA, these broad sense goals incorporate many of the traditional uses, as well as rural and Native American values, deemed important in the Pacific Northwest.

Oregon's broad sense recovery goal for Mid-C steelhead is founded on a belief that citizens throughout the region value and enjoy the substantial ecological, cultural, social, and economic benefits that are derived from having healthy, diverse populations of steelhead. The Middle Columbia Sounding Board (2006) identified the following broad sense recovery goal:

> *Oregon's Mid-Columbia River natural steelhead populations are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) so that they provide significant ecological, social, cultural, and economic benefits.*

Recovery of Mid-Columbia steelhead populations will require actions that preserve, enhance and restore healthy watershed conditions where ecosystem functions, processes and dynamics are intact, including instream conditions, riparian habitat diversity and complexity, and upland watershed health, in concert with complementary management of harvest, hatcheries and hydropower. Recovery is a process that leads to steelhead populations that are not only viable, but that also provide a harvestable surplus for the treaty tribes and for all other citizens of the region.

This vision for broad-sense recovery incorporates ESA delisting goals in the sense that delisting would be achieved *first* during an extended and stepwise process of achieving broad sense recovery goals. ESA delisting criteria are entirely science-based and establish the biologically-based standards required to sustain the DPS. In contrast, broad-sense recovery represents a level of population and DPS performance that will considerably exceed the delisting level.

Recovery Objectives

By the year 2050, proponents of Oregon's Mid-Columbia River Steelhead Recovery Plan intend to achieve the following objectives:

1. Middle Columbia steelhead are viable throughout the historical range and no longer need protection under the ESA;
2. All currently extant Middle Columbia steelhead populations are highly viable;
3. Extirpated populations (e.g. Willow Creek, Crooked River) are restored in a manner that engages landowner cooperation and does not subject landowners to ESA regulation based on the presence of previously extirpated populations until the introduced populations are self-sustaining and become part of the listed DPS;
4. All extant populations of Middle Columbia steelhead are capable of contributing ecological, social, cultural, and economic benefits on a regular and sustainable basis;
5. Working in concert with existing agreements and collaboratively with landowners and resource managers NOAA will define a suite of additional land and water resource management principles and practices that when followed will alleviate liability for possible ESA regulatory consequences to landowners and resource managers;
6. Out-of-basin limiting factors are addressed equitably and in concert with in-basin limiting factors;
7. Landowners, land managers and agencies are provided with guidance on the protection and management of habitats to promote the recovery of Mid-C steelhead; and,
8. Land and resource managers work with communities and other interests in a coordinated manner to achieve broad sense recovery through a shared vision of conservation where options and choices are preserved for future generations.

Viability Criteria and Approach

The ICTRT's biologically based viability criteria provided the stepping stones for assessing the status of populations in the DPS and identifying future conditions that, when met, would describe viable populations. The State of Oregon adopted the ICTRT's viability criteria as its delisting criteria.

Under the approach, viability assessments are first conducted for the independent populations. The population-level assessments provide the basis for evaluating viability at the next hierarchical level, the MPG. The MPGs then need to meet viability criteria for the DPS to be rated as viable. This approach is consistent with the Viable Salmonid Populations (VSP) guidelines (McElhany et al. 2000), as well as related applications by the Puget Sound and Willamette/Lower Columbia TRTs and the Upper Columbia QAR, and information reviewed for listed Interior Columbia ESU and DPS populations. Section 5.1 describes the ICTRT's viability criteria that address these abundance, productivity, spatial structure and diversity considerations. The ICTRT recommends that the criteria be met to remove the DPS from its listed status under the ESA.

Population-level Viability Criteria

According to McElhany et al. (2000): "*A viable population should be large enough to: 1) have high probability of surviving environmental variation observed in the past and expected in the future; 2) be resilient to environmental and anthropogenic disturbances; 3) maintain genetic diversity; and, 4) support/provide ecosystem functions.*"

The viability criteria address four VSP parameters at the population level:

- *Abundance* – the average number of spawners in a population over a generation or more,
- *Productivity* – the performance of a population over time in terms of recruits produced per spawner,
- *Spatial Structure* – a population's geographic distribution and the processes that affect that distribution, and
- *Diversity* – the distribution of genetic, life history and phenotypic variation within and among populations.

The ICTRT grouped these parameters into two categories: measures addressing abundance and productivity, and measures addressing spatial structure and diversity. The viability of an independent population is determined by integrating risks across the four VSP parameters.

Population Abundance and Productivity Parameters

The ICTRT's objective for abundance and productivity criteria is that: abundance should be high enough that 1) in combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent historical patterns of environmental variability; 2) compensatory processes provide resilience to the effects of short term perturbations; and, 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns) (ICTRT 2007).

The ICTRT used the viability curve concept (e.g., LC/W TRT 2003) as a framework for defining population-specific abundance and productivity levels to meet the objective. A viability curve shows the extinction risks posed by different combinations of abundance and productivity. The ICTRT generated viability curves for each population to identify the combinations of abundance and productivity corresponding to a range of extinction risks—1% (very low), 5% (low), and 25% (moderate) over a 100-year period (Figure 1-4). It targeted population level recovery strategies to achieve less than a 5% (low) risk of extinction in a 100-year period. This is consistent with the VSP guidelines and conservation literature (McElhany et al. 2000; NRC 1995).

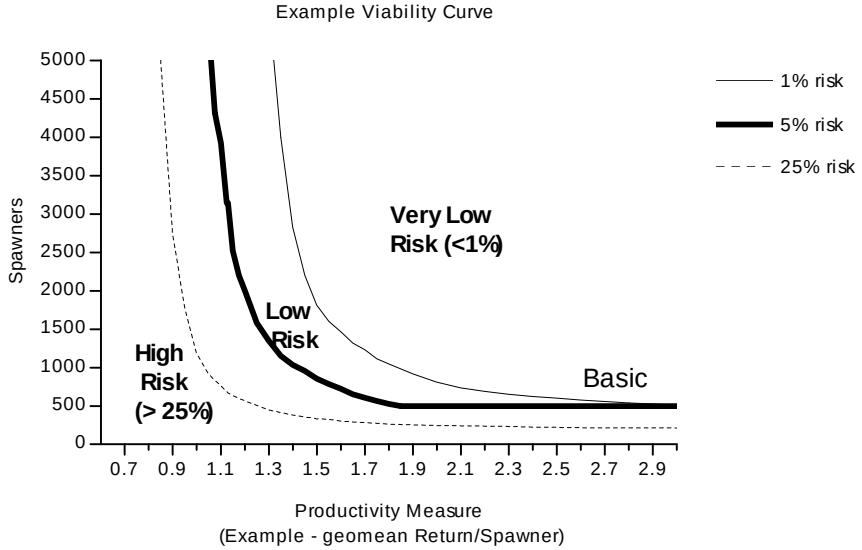


Figure 1-4. Example of Abundance/Productivity viability curve.

The ICTRT established a minimum abundance threshold of 500 individuals for a Basic size population based on its determination that abundance levels below 500 individuals for any population would pose unacceptable risk for inbreeding depression and other genetic concerns. It established higher minimum abundance thresholds incrementally for the three larger population sizes — Intermediate (1,000 spawners), Large (1,500 spawners) and Very Large (2,250 spawners). Viability curves for all four size categories were truncated at the minimum abundance threshold level. The ICTRT also categorized the populations by historical spatial distribution pattern and complexity (Table 1-1).

Table 1-1. Population characteristics and minimum abundance and productivity (at the threshold abundance level) values that represent levels needed to achieve a 95% probability of persistence over 100 years for Oregon Mid-C steelhead populations.

Population	Extant/ Extinct	Life History	Size	Spatial Category	Threshold Abundance	Minimum Productivity
Cascades Eastern Slope Tributaries MPG						
Fifteenmile Creek	Extant	Winter	Basic	C-Trellis	500	1.56
Deschutes River E.	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35
Deschutes River W.	Extant	Summer	Large (Inter.) [a]	B-Dendritic	1,500 (1,000)	1.35
Deschutes/Crooked	Extinct	Summer	Very Large	B-Dendritic	2,250	1.19
John Day River MPG						
L. Main John Day R.	Extant	Summer	Very Large	B-Dendritic	2,250	1.19
NF John Day R.	Extant	Summer	Large	B-Dendritic	1,500	1.26
MF John Day R.	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35
SF John Day R.	Extant	Summer	Basic	B-Dendritic	500	1.56
U. Main John Day R.	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35
Umatilla/Walla Walla Rivers MPG						
Willow Creek	Extinct	Summer	Intermediate	B-Dendritic	1,000	1.35
Umatilla River	Extant	Summer	Large	B-Dendritic	1,500	1.26
Walla Walla River	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35

[a] Large size category is for historically accessible area; intermediate size category is for currently accessible area.

Spatial Structure and Diversity Parameters

The ICTRT identified two primary goals that spatial structure and diversity criteria should address: 1) maintain natural rates and levels of spatially mediated processes, and 2) maintain natural patterns of variation. It also identified mechanisms, factors and metrics for assessing a population's spatial structure and diversity. Mechanisms are biological or ecological processes that contribute to achieving the goals, factors are characteristics of a population or its environment that influence mechanisms, and metrics are conditions that can be measured and assessed at regular intervals to determine whether a population has achieved goals or to evaluate its current risk level.

Goal 1: *Maintain natural rates and levels of spatially-mediated processes.*
Metrics:

a. Number and distribution of spawning areas
b. Spatial extent and range relative to historical
c. Changes in gaps between spawning areas

Goal 2: *Maintain natural levels of variation.*
Metrics:

a. Changes and loss of major life history strategies
b. Variation and loss of phenotypic traits, run timing
c. Genetic variation
d. Spawner composition, proportion and origin of natural spawning hatchery fish
e. Changes in use of major habitat types (ecoregions)
f. Selective mortality factors: Hydrosystem, Hatcheries, Harvest, Habitat

Section 5.1 provides a more detailed discussion of these goals and the mechanisms, factors and metrics for rating spatial structure and diversity risks.

Integrating the Four Parameters

The ICTRT's population level criteria allowed us to identify populations performing at Viable or Highly Viable levels. We identified these populations by using a simple matrix approach that integrates all four viable salmonid population parameters. The abundance/productivity (A/P) risk level combines the abundance and productivity criteria using a viability curve. The spatial structure/diversity (SS/D) risk level integrates across the measures of spatial structure and diversity.

Under this approach, Viable and Highly Viable populations are rated directly as specific combinations of A/P and SS/D risk ratings (Figure 1-5). Populations with a Very Low rating for A/P and at least a Low rating for SS/D are considered to be Highly Viable. Population rated at Moderate or High risk for A/P, or High risk for SS/D have a risk of extinction greater than 5% and are not considered Viable. These individual population ratings are then integrated to determine viability at the MPG level. ICTRT criteria require a minimum number of populations within an MPG to be at or above viable status, with additional MPG populations maintained at sufficient levels to provide for ecological functions and to preserve options for DPS recovery.

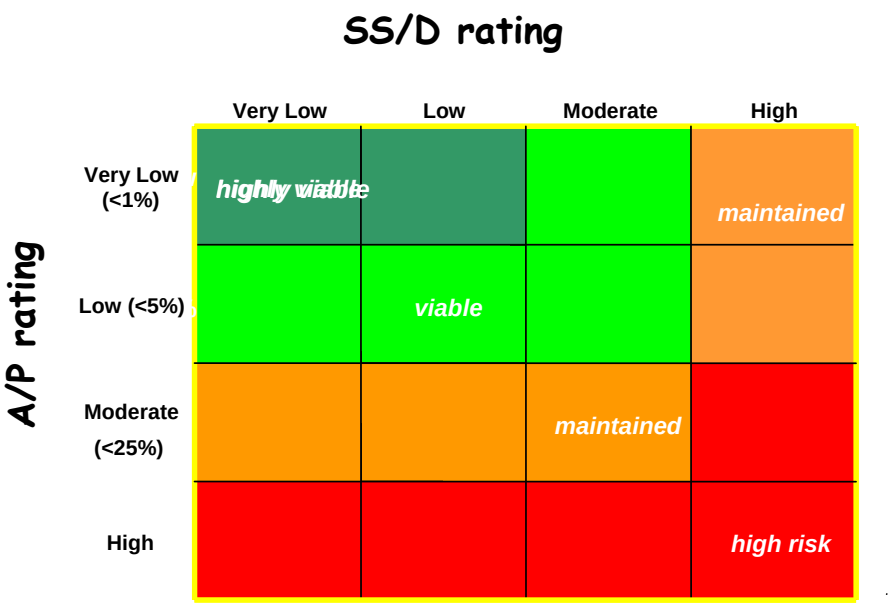


Figure 1-5. Matrix used to integrate Viable Salmonid Population parameter risk ratings and determine overall viability level.

DPS and MPG-level Viability Criteria

The ICTRT framed its ESU/DPS and MPG-level viability criteria to ensure preservation of basic historical metapopulation processes within the DPS, including 1) genetic exchange across populations over a long time frame; 2) the opportunity for neighboring populations to serve as source areas in the event of local population extirpations; 3) population distribution so that they are not all susceptible to a specific localized catastrophic event (ICTRT 2007). Its ESU/DPS-level viability criterion recognizes that MPGs within the DPS likely functioned historically as metapopulations.

DPS-level viability criteria

The ICTRT provided the following criterion to describe the biological characteristics of a viable ESU or DPS:

> All extant MPGs and any extirpated MPGs critical for proper functioning of the ESU or DPS should be at low risk.

MPG-level viability criteria

The ICTRT defined five criteria that a MPG must meet to be regarded as at low risk:

1. At least one-half of the populations historically within the MPG (with a minimum of two populations) must meet viability standards.
2. At least one population must be categorized as being "Highly Viable."
3. Viable populations within an MPG must include some populations classified (based on historical intrinsic potential) as "Very Large", "Large" or "Intermediate" generally

reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.

4. Populations not meeting viability standards should be maintained with a) sufficient productivity so the overall MPG productivity does not fall below replacement, and b) sufficient spatial structure and diversity demonstrated by achieving Maintained standards.
5. All major life history strategies (e.g., summer and winter run-timing) that were present historically within the MPG must be represented in populations meeting viability requirements.

The population level assessments provide the basis for evaluating viability at the MPG level and, in turn, the DPS as a whole. The combined effects of requiring each MPG to sustain a minimum number of viable populations, a representation of larger size classes of populations and major life history patterns, and the maintenance requirement provide for a network of populations that would sustain the DPS. Revisiting population delineation and viability criteria when new information becomes available is considered an essential element of the adaptive management plan that guides implementation.

Threats Criteria

The listing factor (threats) criteria are the measures that NMFS will use to reevaluate the status of the Mid-C steelhead DPS. They are based on the features that were evaluated under section 4(a)(1) when the initial determination was made to list the species for protection under the ESA. Recovery plans are required to contain these criteria. At the time of a delisting decision, NMFS will use the criteria to determine whether the section 4(a)(1) listing factors have been adequately addressed, i.e., whether the underlying causes of decline have been addressed and mitigated and are not likely to re-emerge. The listing factor (threats) criteria, which will be used to reevaluate the status of Oregon's Mid-C steelhead, are included in the DPS-level recovery plan for Mid-C steelhead and are not repeated in this plan. Threats criteria are described in detail in NOAA's Mid-C DPS Recovery Plan.

Potential MPG-level Recovery Scenarios

Several scenarios or combinations of populations would satisfy the MPG level viability criteria for the three MPGs containing Oregon Mid-C steelhead populations. The populations included in each of these scenarios were selected based on unique characteristics (e.g. run timing, population size, genetic characteristics), major production areas in the MPG, and spatial distribution of the populations.

The State of Oregon aims to improve more than the minimum number of populations identified in the recovery scenarios for viability. We acknowledge that targeting only the minimum number of populations would likely result in failure to achieve our goals. There is considerable uncertainty in the management actions and how effective they will be in improving population viability. This uncertainty will result in some targeted populations not achieving the desired status. To hedge against this uncertainty, more than the minimum number of populations must be targeted for viable status. Therefore, we also seek to improve all extant Oregon populations

in the MPGs to be maintained at sufficient levels to provide for ecological functions and to preserve options for DPS recovery. This is consistent with ICTRT criteria that recommend that more than the minimum number of populations be improved to a viable status.

Cascades Eastern Slope Tributaries MPG
The following recovery scenario exists for the Cascades Eastern Slope Tributaries MPG:

Population Characteristics:

Independent Populations	Size Category	Life History Type
White Salmon (extirpated)	Basic	Unknown
Klickitat River	Intermediate	Summer/winter
Deschutes River Eastside	Intermediate	Summer
Deschutes River Westside	Large	Summer
Crooked River (extirpated)	Very Large	Summer
Fifteenmile Creek	Basic	Winter
Rock Creek	Basic	summer

Recovery Scenario:

- Four populations must meet viability criteria, one of which must meet highly viable criteria.
- Fifteenmile Creek is the only winter population and thus must meet viability criteria.
- One Large or Very Large population must meet viability criteria. Deschutes River Westside is the only extant population that can meet this criterion.
- Two Intermediate populations must meet viability criteria. Deschutes River Eastside and Klickitat River are the only populations that can meet this criterion.

Recommendations: To achieve viable status in the Cascades Eastern Slope Tributaries MPG, the Fifteenmile Creek, Deschutes River Eastside, Deschutes River Westside, and Klickitat populations must all achieve viable status. One of these populations must be highly viable. The Rock Creek population must be maintained.

John Day River MPG
Recovery scenarios for the John Day River MPG are presented below:

Population Characteristics:

Independent Populations	Size Category	Life History Type
Lower Mainstem John Day River	Very Large	Summer
South Fork John Day River	Basic	Summer
Middle Fork John Day River	Intermediate	Summer
North Fork John Day River	Large	Summer
Upper Mainstem John Day River	Intermediate	Summer

Recovery Scenario:

- Three populations must meet viability criteria, one of which must meet highly viable criteria.

- Two Large or Very Large populations must meet viability criteria. Lower John Day and North Fork John Day are the only populations that can meet this criterion.
- One Intermediate population must meet viability criteria. The Upper Mainstem John Day or Middle Fork John Day populations could meet this criterion.

Recommendations: To achieve viable status in the John Day River MPG, the Lower Mainstem John Day River, North Fork John Day River, and either the Middle Fork John Day River or Upper Mainstem John Day River populations must achieve viable status. One of these populations must be highly viable. The South Fork John Day River population must be maintained.

Umatilla/Walla Walla Rivers MPG
The following recovery scenarios exist for the Umatilla/Walla Walla MPG:

Population Characteristics:

Independent Populations	Size Category	Life History Type
Willow Creek (extirpated)		
Umatilla River	Large	Summer
Walla Walla River	Intermediate	Summer
Touchet River	Intermediate	Summer

Recovery Scenario:
- Two populations must meet viability criteria, one of which must meet highly viable criteria.
- One Large or Very Large population must meet viability criteria. The Umatilla River is the only population that can meet this criterion.

Recommendations: To achieve viable status in the Umatilla/Walla Walla Rivers MPG, the Umatilla River population and either the Walla Walla River or Touchet River population must achieve viable status. One of these populations must be highly viable. All remaining extant populations must be maintained.

1.6 Current Population Status

Assessing the current status of the populations according to the viability criteria is a critical first step in determining a path towards MPG and DPS viability. Following ICTRT guidelines, we completed viability assessments for Oregon's ten extant Mid-C steelhead populations. The assessments describe the current status of the populations relative to the abundance/productivity and spatial structure/diversity viability criteria.

Overall, the viability assessments show that only three of Oregon's Mid-C steelhead populations currently meet the viability criteria. The North Fork John Day population is highly viable and the Fifteenmile Creek and Deschutes River Eastside populations are viable. The remaining populations rated as either maintained or extinct. Assessment findings are provided for each of the ten populations in the population summaries (later in this section-1.14) and in Section 6 of

the recovery plan. Appendix B contains the detailed individual population viability assessments, including population-specific data sources and methods used to estimate abundance.

We also completed viability assessments for the three MPGs containing the Oregon populations. The assessment findings indicate that the three MPGs are currently below viable status based on the status of the constituent populations. These findings are shown below in Tables 1-2 through 1-4.

Cascades Eastern Slope Tributaries MPG

Findings: The Cascades Eastern Slope Tributaries MPG is currently below viable status. The Fifteenmile Creek and the Deschutes River Eastside are viable. The Deschutes River Westside population does not meet viability criteria. The Deschutes Crooked River population is extinct.

Table 1-2. Viability assessment results for Mid-C steelhead populations in the Cascades Eastern Slope Tributaries MPG.

Population	Extant/ Extinct	Abundance		Productivity		A/P Risk	Goal A Natural Processes Risk	Goal B Diversity Risk	Integrated SS/D Risk	Overall Population Viability Rating
		Mean	Lower 90% CI	Mean	Lower 90% CI					
Fifteenmile Creek	Extant	703	481	1.82	1.23	Low	Very Low	Low	Low	Viable
Deschutes River Eastside	Extant	1,599	896	1.89	1.10	Low	Low	Moderate	Moderate	Viable
Deschutes River Westside	Extant	456	306	1.05	0.76	High	Low	Moderate	Moderate	High Risk
Deschutes Crooked River	Extinct	0	NA	0	NA	Extinct	NA	NA	NA	Extinct

John Day River MPG

Findings: The John Day River MPG is currently below viable status. The North Fork population is highly viable; however, all of the other John Day River populations were below viable status.

Table 1-3. Viability assessment results for Mid-C steelhead populations in the John Day River MPG.

Population	Extant/ Extinct	Abundance		Productivity		A/P Risk	Goal A Natural Processes Risk	Goal B Diversity Risk	Integrated SS/D Risk	Overall Population Viability Rating
		Mean	Lower 90% CI	Mean	Lower 90% CI					
Lower Mainstem John Day River	Extant	1,800	1,065	2.99	1.91	Moderate	Very Low	Moderate	Moderate	Maintained
North Fork John Day River	Extant	1,740	1,375	2.41	1.62	Very Low	Very Low	Low	Low	Highly Viable
Middle Fork John Day River	Extant	756	508	2.45	1.81	Moderate	Low	Low	Low	Maintained
South Fork John Day River	Extant	259	168	2.06	1.26	Moderate	Very Low	Low	Low	Maintained
Upper Mainstem John Day River	Extant	524	399	2.14	1.15	Moderate	Very Low	Moderate	Moderate	Maintained

Umatilla/Walla Walla Rivers MPG

Findings: The Umatilla/Walla Walla Rivers MPG is currently below viable status because the Umatilla and Walla Walla populations do not meet viability criteria.

Table 1-4. Viability assessment results for Mid-C steelhead populations in the Umatilla/Walla Walla Rivers MPG.

Population	Extant/ Extinct	Abundance		Productivity		A/P Risk	Goal A Natural Processes Risk	Goal B Diversity Risk	Integrated SS/D Risk	Overall Population Viability Rating
		Mean	Lower 90% CI	Mean	Lower 90% CI					
Willow Creek	Extinct	0	NA	0	NA	Extinct	NA	NA	NA	Extinct
Umatilla River	Extant	1,472	988	1.50	1.11	Moderate	Moderate	Moderate	Moderate	Maintained
Walla Walla River	Extant	650	459	1.34	1.05	Moderate	Low	Moderate	Moderate	Maintained

1.7 Gap Analysis

The viability assessment results were used to determine the "gap" between the current status and the status required to meet the viability criteria. The gap analysis addresses the four VSP parameters: abundance, productivity, spatial structure and diversity. This analysis allowed us to identify viability impairments at the population level and inform development of appropriate actions to address impairments and, thus, "close the gaps."

The ICTRT conducted the abundance/productivity gap analyses for Mid-Columbia steelhead populations. The ICTRT defined the abundance/productivity gap as the quantitative relative amount of change in survival or capacity that is required for a population to improve from current status to a specific viability level. The gap analysis provides estimates of the magnitude of survival or capacity change that are needed to reach viability criteria for 25%, 5% and 1% probability of extinction over a 100-year timeframe as defined by the viability curves.

Our recovery planners performed the spatial structure/diversity gap analyses for the Oregon populations. The analyses included several steps: 1) for each population, we identified all spatial structure and diversity metrics with ratings of moderate or high risk; 2) for the metrics rated moderate, we determined if the rating was a result of changed status from intrinsic conditions or if the rating was a result of an intrinsic moderate risk for the metric; and 3) we characterized spatial structure and diversity gaps for each population as those metrics that rated high risk and those metrics that rated moderate risk because the current status is impaired relative to the intrinsic condition.

Gap analysis results for individual populations are provided in the population summaries (later in this section-1.14) and in Section 7.

1.8 Limiting Factors and Threats

Section 8 describes limiting factors and threats to the viability of Mid-C steelhead in Oregon. The findings were identified based on many sources of information, including the Mid-C steelhead Expert Panel's report, subbasin plans, ODEQ reports, ICTRT reports, NOAA's limiting factors modules, ODFW reports, hydrosystem biological opinion remand documents, and numerous other sources. The limiting factors and threats analyses serve as an essential foundation for the development and prioritization of management actions across the entire lifecycle. We used the following definitions of limiting factors and threats for our assessment.

> *Limiting Factors*: The physical, biological, or chemical conditions of the environment and associated ecological processes and interactions (e.g., habitat connectivity, water quality, physical habitat quality, etc.) that influence Mid-C steelhead viable salmonid population parameters, including abundance, productivity, spatial structure, and diversity.
>
> *Threats:* Threats are human actions (e.g., fishing, operation of hatcheries, operation of hydrosystem, land use practices, etc.) or natural events (e.g., flood, drought, volcano, etc.) that cause or contribute to limiting factors. Threats may influence one or multiple life stages and may occur in the present or future or have occurred in the past.

Key findings are summarized below and population-specific limiting factors and threats are identified in the population summaries in Section 1.14. Section 8.1 provides a broad level perspective of the primary limiting factors and threats across and within Oregon's Mid-C steelhead populations. This broader look is followed by more detailed, in-depth discussions of limiting factors and threats in Section 8.2 (Tributary Habitat), 8.3 (Hydrosystem), 8.4 (Estuarine and Plume Habitat), 8.5 (Harvest), 8.6 (Hatchery), and 8.7 (Predation and Competition).

Land Use

Tributary habitat degradation from past and/or present land use remains a key concern for all populations. Steelhead have been adversely affected by modified and reduced streamflows, impaired water quality due to elevated water temperatures and agricultural chemicals, impaired upstream and downstream fish passage, degraded channel structure and complexity (including riffles, pools and large woody debris), loss of riparian vegetation, reduced floodplain connectivity, and excessive levels of fine sediments caused by altered sediment routing. Threats contributing to these factors include agricultural, forestry and grazing practices that negatively impact steelhead growth and survival, dams and other barriers, water withdrawals, roads and channel manipulations. The Mid-C Expert Panel identified land use as having the most key concerns of any of the threat categories because, for most populations, the greatest impairment to viability has resulted from changes to the tributary spawning, rearing, and migration habitats.

We examined seven general types of tributary habitat limiting factors during our analysis. The factors are often interrelated.

- *Degraded floodplain connectivity and function*: Loss, impairment or degradation of floodplain connectivity; access to previously available habitats (seasonal wetlands, off-

channel habitat, side channels); and a connected and functional hypotheic zone. Includes reduced overwinter habitat and channel habitat. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

- *Degraded channel structure and complexity*: Loss, impairment or degradation of channels; a suitable distribution of riffles and functional pools; functional amounts and sizes of large woody debris or other channel structure. Includes reduced summer rearing habitat, degraded spawning habitat, reduced diversity and structure (wood, boulders, etc.), inadequate quantity or depth of pools, loss of side and braided channels. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

- *Degraded riparian areas and LWD recruitment*: Loss, degradation or impairment of riparian conditions important for production of food organisms and organic material, shading, bank stabilizing by roots, nutrient and chemical mediation, control of surface erosion, and production of large-sized woody material. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

- *Altered hydrology*: Changes in the hydrograph that alter the natural pattern of flows over the seasons, causing inadequate flow, scouring flow, or other flow conditions that inhibit the development and survival of salmonids. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

- *Degraded water quality*: Degraded or impaired water quality due to abnormal temperature, or levels of suspended fine sediment, dissolved oxygen, nutrients from agricultural runoff, heavy metals, pesticides, herbicides and other contaminants (toxics). Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

- *Altered sediment routing*: Altered sediment routing leading to an overabundance of fine-grained sediments, excess of course-grained sediments, inadequate course-grained sediments and/or contaminated sediment. Includes excessive fine sediment that reduces spawning gravel or increases embeddedness. Life stages affected: egg-to-parr survival.

- *Impaired fish passage*: The total or partial human-caused blockage to previously accessible habitat that eliminates or decreases migration ability or alters the range of conditions under which migration is possible. This may include seasonal or periodic total migration blockage. Includes dams, culverts, seasonal push up dams, unscreened diversions, and entrainment in irrigation diversions. Life stages affected: smolt migration, adult migration, juvenile upstream migration due to thermal blockage or water availability.

Climate change is expected to increase the loss and degradation of steelhead habitat. Many of the environmental attributes that will be influenced by climate change (temperature and hydrograph) are those that have already been influenced significantly by past land use and are currently considered key limiting factors. Environmental changes associated with climate change that pose particular threats to salmonid viability include: increased air and stream

temperatures; reduced snow pack and a shift in precipitation from snow to rain; altered hydrographs with earlier and higher peak flows, and lower summer-fall flows; more frequent extreme storm events; increased periods of drought; changing ocean temperatures and current patterns; and more frequent and severe fire events (O'Neal 2002; Mote et al. 2003; ISAB 2007a; Michael and O'Brien 2008). Such environmental changes will impact all life stages of Oregon's Mid-Columbia River steelhead. The magnitude of environmental change will vary considerable across ecoregions; however, habitats at lower elevations east of the Cascade Mountains in the southern portion of the Columbia River basin will generally experience the greatest level of change (ISAB 2007a).

Hydrosystem

The mainstem Columbia River hydrosystem is considered a primary threat to the viability of Oregon's Mid-C steelhead populations. Specific viability concerns identified by the Mid-C Expert Panel related primarily to effects of delayed upstream passage (adults), direct and indirect mortality on downstream migrants (juveniles), alteration of the hydrograph (mainstem and estuary flow regime), depletion of historically available nutrients, and degraded rearing and food resources for both presmolts and smolts in the Columbia River.

Results of the BiOp Framework Work Group support this conclusion. NMFS created the work group to provide scientific expertise during development of its Biological Opinion (BiOp) evaluating effects of operations of the FCRPS — including estimating the relative magnitude of human-caused mortality factors influencing Mid-C steelhead and other Interior Columbia River salmon and steelhead populations. During this evaluation, the work group found that the FCRPS hydrosystem had the greatest relative impact on the Mid-C steelhead populations compared with other human-induced mortality effects (Step 4 Report 2006) (Table 8-1). The ICTRT reached a similar conclusion in September 2006, when members rated the mainstem Columbia River hydrosystem as a major limiting factor for all populations in the DPS. Oregon's recovery planning team also determined that the mainstem hydropower system represents a primary threat to the viability of Oregon Mid-C steelhead populations. The Expert Panel's findings were generally consistent with the BiOp Framework Work Group's findings on magnitude of human-induced mortality, however, the Expert Panel considered the mainstem Columbia hydrosystem a threat of moderate concern to the populations and generally considered legacy and current land use as a greater threat than the hydrosystem.

Impacts from the mainstem Columbia River hydrosystem increase somewhat for each of the populations in direct relation to the number of dams the fish must pass during their migration to and from the Pacific Ocean. Mid-Columbia steelhead populations pass one to four Columbia River dams: the Fifteenmile Creek population passes one dam; Deschutes River populations pass two dams; John Day River and Umatilla River populations pass three dams; and the Walla Walla River population passes four dams.

Several hydroelectric dams on Columbia River tributaries also pose significant threats to the viability of specific populations. The Pelton-Round Butte Complex on the Deschutes River at RM 100 significantly affects the Deschutes Westside population and to a lesser extent the Deschutes Eastside population. It blocks all passage to historical habitat above the dam,

particularly in Whychus Creek, Metolius River and Crooked River. The Boyd Hydro Project on the Umatilla River and Twin Reservoirs Hydro Project on Mill Creek, a tributary to the Walla Walla River affect the Umatilla and Walla Walla steelhead populations.

Estuarine and Plume Habitat

The Columbia River estuary and plume have changed considerably over the last 200 years. The estuary tidal prism is now about 20% smaller, due mostly to dike and filling practices used to convert the floodplain to agricultural, industrial, commercial, and residential uses. Instream flows entering the estuary also have changed dramatically—there has been a 44% decrease in spring freshets or floods, and the annual timing, magnitude, and duration of flows no longer resemble those of the historical hydrograph in the Columbia River (Jay and Kukulka 2002).

Scientists generally believe that steelhead and other stream-type salmonids are particularly affected by changes in plume habitat conditions and by predation in the estuary and plume (Lower Columbia River Estuary Partnership (LCREP) 2006). The plume is believed to function as habitat, as a transitional saltwater area, and as refugia for juvenile salmonids as they prepare for ocean life (Fresh et al. 2005; LCREP 2006). Changes in the Columbia River hydrograph alter both the size and structure of the plume during the spring and summer months (NPCC 2000). Changes in the hydrograph also affect plume habitat by reducing fine-sediment inputs leaving the estuary.

Harvest

Steelhead are affected by harvest during several life stages from pre-smolts taken in trout fisheries to adults taken in commercial, recreational and tribal fisheries primarily in the mainstem Columbia River and tributaries. However, given current management regulations for mainstem Columbia River and tributary fisheries, harvest is not considered a primary or secondary threat due to the low impact on viability. The ICTRT identified harvest-related effects as a secondary level limiting factor and the Mid-C Expert Panel did not identify harvest as either a key or secondary concern for Oregon's Mid-C steelhead populations. The panel, however, did express concerns over the impact that mortality associated with catch and release fisheries have on Westside and Eastside Deschutes populations.

Hatcheries

Out-of-DPS hatchery strays pose significant risk to many of Oregon's Mid-C steelhead populations, particularly to the Eastside and Westside Deschutes and John Day populations. Viability assessments, summarized in Section 6 of this document and presented in Appendix B, identified that a significant proportion of spawners in the Deschutes River and John Day River populations were out-of-DPS strays. In addition, these populations were rated at high risk for spawner composition due to the abundance of strays. Biologists remain especially concerned regarding the continuing detrimental impact of stray out-of-DPS hatchery fish in natural spawning areas on the genetic traits and productivity of these natural populations. Hatchery programs operated within the Mid-C steelhead DPS — including the Umatilla, Walla Walla and Westside Deschutes subbasins — also create some risks. The Mid-C Expert Panel ranked the

impact of hatchery strays as a key concern to the Eastside and Westside Deschutes and Lower John Day populations, and as a secondary concern to the Umatilla and Walla Walla populations.

Predation

The Expert Panel listed predation is a primary concern for juvenile and adult steelhead in the Columbia River estuary and plume. Estuary habitat modifications have increased the number and/or predation effectiveness of Caspian terns, cormorants, and gull species (Fresh et al. 2005). The increasing abundance of native pinnipeds has resulted in increased predation on adult salmonids to a point of concern. Panelists identified predation by non-native piscivorous fish on pre-smolts and smolts in the mainstem Columbia as a secondary concern for all Mid-C steelhead populations.

Climate Change

Climate change will alter environmental conditions across the entire life cycle for all life stages of Oregon's Mid-Columbia River steelhead. There remains considerable uncertainty regarding the magnitude of loss and degradation of salmonid habitat in the Columbia Basin that will result from climate change. The magnitude of environmental change will vary considerable across ecoregions and thus will have different impacts on viability of steelhead populations within the Mid-C DPS. In general, habitats at lower elevations east of the Cascade Mountains in the southern portion of the Columbia River basin, which encompasses the Oregon Mid-C area, will experience the greatest level of change (ISAB 2007a).

Many of the environmental attributes that will be influenced by climate change (temperature and hydrograph) are those that have already been influenced significantly by past land use and are currently considered key limiting factors. The degree to which climate change will impact a given population is partially dependent on the degree to which natural processes have already been altered. A number of reviews have recently been completed that characterize potential climate change impacts in the Pacific Northwest (O'Neal 2002; Mote et al. 2003; ISAB 2007a; Michael and O'Brien 2008). The environmental changes most often described as significant threats to salmonid viability include:

- Increased air and stream temperatures
- Reduced snow pack and a shift in precipitation from snow to rain
- Altered hydrographs with earlier and higher peak flows, and lower summer-fall flows
- More frequent extreme storm events
- Increased periods of drought
- Changing ocean temperatures and current patterns
- More frequent and severe fire events

We conducted an analysis to assess population-specific vulnerability to climate change impacts. We developed a climate change potential vulnerability risk index based on projected future springtime water availability, projected future stream temperatures, and historical variation in precipitation. Our analysis indicates that few of the HUC6s in Oregon's Mid-C populations are at low or very low risk. Many populations have the entire geographic area within the population

boundaries rated as moderate or high risk. The combination of environmental characteristics that are forecasted to change under future climate scenarios will threaten capacity, productivity, diversity, and spatial structure from both lower elevations upward and higher elevations downward. Temperature changes will influence lower elevation areas significantly while higher elevation areas will be influenced most by hydrograph changes.

1.9 Recovery Strategies and Actions

Achieving recovery for the DPS will depend on restoring the viability of extant populations in major population groups to levels that support the proper functioning of the DPS. Recovery strategies for Oregon's Mid-C steelhead populations involve substantial reductions in the threats across all categories (tributary habitat, hydrosystem, estuary and plume habitat, harvest, hatcheries, and predation and competition).

An Integrated Approach

The delisting and broad sense recovery goals, assessments of current status and viability gaps, and limiting factors and threats analysis served as essential building blocks for identifying recovery strategies and actions. The plan's strategies and actions address the multiple limiting factors and threats that affect steelhead viability throughout their life cycle:

- Tributary habitat strategies and actions (Section 9.3) call for the protection of the highest quality habitats, maintenance of existing unimpaired habitats and ecosystem functions that support population viability, and habitat restoration through passive and active measures. Restoration strategies are linked directly to the limiting factors and aim to improve tributary spawning, rearing and migration conditions by restoring instream, riparian and upland habitat conditions, providing passage and floodplain connectivity, and addressing water quality and flow concerns. Actions identified under each strategy define the specific work needed to fill the gap between current conditions and what is needed in the long term to fully achieve the strategy. Actions differ from strategies in that they address specific needs for a specified geographic area, program deficiencies, as well as biophysical habitat impairments and threats. Together, the strategies and actions represent a complete list of needs, somewhat unconstrained by logistic and financial concerns.

- Hydrosystem strategies and actions (Section 9.4) primarily address configurations and operations of the Columbia River hydropower system. They range from improving juvenile and adult steelhead passage and survival at particular dams to addressing flow and temperature issues. These strategies and actions may be revised before completion of the final recovery plan to be consistent with adopted revisions of the 2004 FCRPS BiOp Remand.

  The section also identifies strategies and actions to adjust hydropower operations and facilities in the Umatilla and Walla Walla river systems, and to increase the quantity of spawning and rearing habitat available to Deschutes River Westside steelhead, and to a lesser extent Deschutes River Eastside steelhead, by restoring passage to historical

habitats in the middle and upper Deschutes drainage. Strategies and actions will also restore steelhead access to blocked historical habitats in the Crooked River area.

- Estuarine and plume habitat strategies and actions (Section 9.5) improve steelhead rearing conditions and survival in the Columbia River estuary and plume by restoring estuarine riparian conditions, removing dikes and protecting off-channel habitats.

- Harvest strategies and actions (Section 9.6) protect steelhead in the ocean, mainstem Columbia River and tributaries by maintaining low impact fisheries and attempting to increase harvest of stray hatchery spawners, thus reducing abundance of out-of-DPS hatchery strays.

- Hatchery strategies and actions (Section 9.7) address ecological and genetic effects on Oregon Mid-C steelhead from hatchery management programs in and outside the DPS. They include reducing the abundance and proportion of out-of-DPS hatchery strays spawning naturally in Oregon's Mid-C steelhead populations. They also help restore natural production in historically utilized habitats of the Deschutes Westside, Crooked River, and Umatilla River population areas.

- Predation and competition strategies and actions (Section 9.8) seek to reduce predation by pinnipeds, birds, and piscivorous fish on salmon and steelhead in the Columbia River estuary and mainstem.

Together, the strategies and actions are framed to close viability gaps, reach delisting status, and progress toward broad sense recovery goals. Table 1-5 shows the strategies and types of actions that will be implemented to address all factors limiting recovery of Oregon Mid-C steelhead populations throughout their lifecycle. The highest priority tributary-level strategies, actions and priority areas are also identified for each population (later in this section-1.14).

Table 1-5. Integrated approach to address all factors limiting recovery of Oregon's Mid-C steelhead populations.

Strategies	Populations Addressed	Types of Actions	Limiting Factors and Threats Addressed
Tributary Habitat			
Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	All populations	Protect highest quality habitats through acquisition and conservation. Adopt and manage Cooperative Agreements. Conserve rare and unique functioning habitats. Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	Degradation of tributary habitat-forming processes and functions (loss of channel structure, floodplain connectivity, riparian vegetation, and LWD recruitment)
Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	All populations	Provide passage at Pelton-Round Butte Complex. Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures. Provide screening at 100% of irrigation diversions. Replace screens that do not meet criteria.	Loss of historical habitat because of blocked or impaired fish passage (dams, culverts, unscreened diversions)
Maintain and restore floodplain connectivity and function.	All populations	Reconnect side channels and off-channel habitats to stream channels. Restore wet meadows. Reconnect floodplain to channel.	Degraded floodplain connectivity and function (loss of off-channel habitat, side channels, connected hypotheic zone)

Strategies	Populations Addressed	Types of Actions	Limiting Factors and Threats Addressed
Restore degraded and maintain properly functioning channel structure and complexity.	All populations	Place stable wood and other large organic debris in streambeds. Stabilize streambanks. Restore natural channel form.	Degraded channel structure and complexity (loss of spawning and rearing habitat, LWD, pools)
Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	All populations	Restore natural riparian vegetative communities. Develop grazing strategies that promote riparian recovery.	Degraded riparian condition (native riparian vegetative communities, LWD recruitment)
Restore natural hydrograph to provide sufficient flow during critical periods	All populations	Implement agricultural water conservation measures. Improve irrigation conveyance and efficiency. Lease or acquire water rights and convert to instream.	Altered hydrology (low flow, scouring peak flows due to degraded watershed conditions, streamflow alterations and/or withdrawals for irrigation and other uses)
Improve degraded water quality and maintain unimpaired water quality	All populations	Reduce chemical pollution inputs. Apply BMPs to animal feeding operations. Restore natural functions and processes through above remediation actions.	Degraded water quality (high temperatures, nutrients, pesticides and other chemicals)
Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	All populations	Achieve 95% conversion to no till farming. Upgrade or remove problem forest roads. Restore native upland plant communities. Employ BMPs to forest practices, livestock grazing, road management and agricultural practices.	Altered sediment routing and runoff patterns due to upland management activities.
Estuarine and Plume Habitat			
Restore degraded estuarine and plume habitats and associated ecological processes.	All populations	Protect/restore riparian areas Remove pile dikes Protect remaining high-quality off-channel habitat Breach or lower dikes and levees Identify and reduce sources of pollutants Monitor and restore contaminated sites	Degraded estuarine and nearshore marine habitat reduces refugia available to juvenile steelhead in Columbia River estuary and plume as they prepare for ocean life.
Hydropower Systems			
Operate the FCRPS to more closely approximate the shape of the natural hydrograph to enhance flows and water quality to improve juvenile and adult fish survival.	All populations	Draft storage reservoirs (Libby, Hungry Horse, Grand Coulee, and Dworshak) in attempt to meet seasonal and weekly flow objectives in the lower Columbia River during July and August. Pursue negotiations with Canada to provide 1 million acre feet of storage to augment summer flows. Meet Non-Treaty storage refill responsibilities and pursue a new long-term agreement on use of non-treaty space in Canadian reservoirs. Implement drafts and other measures to improve flows during the lowest 20th percentile years. Implement Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake rivers.	Altered steelhead migration conditions and delayed passage due to hydrosystem development and operations in mainstem Columbia River.
Modify Columbia and Snake River dams to maximize juvenile and adult survival.	All populations.	Implement project specific configurations and operations at the eight mainstem dams on the lower Snake and Columbia rivers.	Altered juvenile and adult steelhead migration conditions due to mainstem Columbia River hydrosystem.
Implement spill and juvenile transportation improvements at Columbia and Snake rivers dams.	All populations.	Provide spill to improve juvenile fish passage. Implement interim transportation program to improve survival of transported fish.	Altered juvenile and adult steelhead migration conditions due to mainstem Columbia River hydrosystem.
Operate and maintain juvenile and adult fish passage facilities at Corps mainstem projects to maintain biological performance.	All populations.	Corps will operate juvenile and adult passage facilities year around with the regionally coordinate Fish Passage Plan.	Altered juvenile and adult steelhead migration conditions due to mainstem Columbia River hydrosystem.
Restore sustainable natural steelhead production to	Deschutes Westside Deschutes Eastside	Develop downstream collection and passage through Pelton-Round Butte Complex.	Tributary hydrosystem operations and configurations block access

Strategies	Populations Addressed	Types of Actions	Limiting Factors and Threats Addressed
blocked habitats in the Deschutes River Westside, Deschutes River Eastside and extinct Crooked River populations.	Crooked River	Improve flow patterns through reservoir for juvenile migration. Modify hydro operations to restore water quality.	to historical habitats and alter habitat conditions.
Improve hydrosystem operations and facilities to enhance steelhead survival and viability.	Umatilla River Walla Walla River	Modify bypass flows at Boyd Project as needed to mimic instream water right. Modify fish passage facilities at Boyd Project to meet current standards. Remove weir panels from diversion dam at Boyd Project during non-operation. Maintain trash racks at Boyd Project. Modify fishway at Twin Reservoirs Project to meet juvenile fish passage standards.	Tributary hydrosystem operations and configurations impair passage and alter habitat conditions.
Harvest			
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	All populations	Maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	Commercial, recreational and tribal fisheries in ocean, mainstem Columbia River and tributaries
Utilize tributary harvest to reduce abundance and proportion of stray hatchery spawners.	Deschutes Westside Deschutes Eastside John Day MPG	Develop educational outreach program to promote use of selective recreational fisheries to reduce the number of out-of-basin hatchery strays.	Straying of out-of-DPS hatchery spawners into tributary spawning grounds.
Reduce catch and release mortality on natural-origin fish in John Day Basin.	John Day MPG	Promote voluntary curtailment of fishing at higher water temperatures (above 21°C) to reduce hook-and-release mortality	Adverse effects of tributary harvest on natural steelhead.
Improve quality of harvest information and impacts on natural-origin fish in John Day Basin.	John Day MPG	Expand the creel surveys to monitor fisheries effort and catch.	Adverse effects of tributary harvest on natural steelhead.
Hatchery			
Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish.	Potential risk for all populations. Significant risk for Deschutes Eastside, Deschutes Westside and Lower John Day populations.	Implement representative coded-wire-tagging program so all hatchery stocks have adequate CWT groups released annually.	Straying of out-of-DPS hatchery fish into natural spawning grounds.
Reduce uncertainty in abundance and proportion of hatchery strays spawning naturally.	Fifteenmile Creek Deschutes Eastside All John Day populations	Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys and other methods.	Straying of out-of-DPS hatchery fish into natural spawning areas.
Reduce abundance and proportion of stray hatchery fish that spawn naturally.	Deschutes Eastside Deschutes Westside Umatilla River Walla Walla River	Construct, improve trapping facilities and expand operations to remove strays. Eliminate adult hatchery strays above Nursery Bridge Dam. Recommend development of alternative broodstocks to reduce stray rates for programs that contribute significantly to stray problem.	Straying of out-of-DPS hatchery fish into natural spawning areas.
Reduce genetic risks associated with Round Butte Hatchery Program.	Deschutes Westside	Investigate opportunities and risks associated with incorporating naturally produced Deschutes River summer steelhead into RBH broodstock.	Inside-DPS hatchery genetic risks
Restore natural production into historically utilized habitats.	Deschutes Westside Crooked River Umatilla River	Develop plan for steelhead reintroduction into historical habitat above Pelton-Round Butte Complex when passage is restored. Re-establish natural production in Little Butter and Butter creeks and some minor spawning areas.	Risks related to steelhead reintroductions to historical habitat using inside-DPS hatchery fish.
Reduce genetic influence of hatchery fish in hatchery	Umatilla River	Eliminate use of hatchery produced adults in the broodstock.	Potential divergence in genetic and phenotypic traits between

Strategies	Populations Addressed	Types of Actions	Limiting Factors and Threats Addressed
broodstock.			hatchery and natural-origin steelhead.
Reduce interactions between residual hatchery steelhead and natural steelhead.	Umatilla River	Assess degree of impact.	Risk of hatchery fish competing with and preying on natural steelhead juveniles
Reduce potential negative ecological interactions between coho salmon and natural steelhead.	Umatilla River	Reduce number of hatchery coho released in Umatilla River and relocate releases downstream to areas not currently important to steelhead production.	Potential for coho smolts to compete with juvenile steelhead for prey resources and space
Predation and Competition			
Reduce predation and competition in the Columbia River mainstem, estuary and plume.	All populations	Reduce predation by pinnipeds Redistribute Caspian terms Redistribute cormorants	Increased predation on steelhead due to degraded estuarine and plume habitats, and to hydrosystem development and operations in mainstem Columbia River.

Building on Current Efforts

We recognize that reversing the decline of populations, life histories and habitats requires use of well-formulated, scientifically sound approaches. In many areas, effective steps have already been taken or are currently underway that will improve the status of different Oregon Mid-C steelhead populations. In tributary watersheds state and federal natural resource managers, tribes, local governments, watershed councils, soil and water conservation districts, non-profit organizations, local land owners and others continue to improve stream conditions to enhance steelhead populations throughout their freshwater life stages. They are also improving land use practices on uplands and floodplains that are allowing natural ecosystem functions and processes to recover.

Similar efforts are underway to address other threats. In the Columbia River estuary, various parties are working to improve estuarine and plume habitat conditions and reduce predation. In the mainstem Columbia River, hydrosystem managers and fish resource managers continue to refine hydropower system operations to address some needs for survival and recovery of the Mid-C steelhead DPS and other ESA-listed salmon and steelhead. Hatchery programs operated within the DPS have also been modified over the past 10 years to reduce threats and improve contribution to recovery. In addition, extensive harvest management changes in both the mainstem and tributaries have been implemented to reduce the impacts of fisheries.

This plan is designed to build on these past and current efforts. Section 9 identifies many of these efforts along with their sufficiency and areas in need of improvement so that future actions expand from and improve their effectiveness. Spreading the responsibility among a range of parties lessens the cost to any one group, increases the certainty of success, and compounds the benefits of moderate improvements in each factor.

Strategic Guidance and Prioritization Considerations for Plan Implementation

Achieving recovery for the Mid-C steelhead DPS will require intensive effort by individuals at the regional, watershed and local levels. Many recovery efforts will need to be conducted in concert to address overlapping causes that impair population viability and disrupt ecosystem functions.

Unfortunately, all of the management actions needed to reach recovery goals cannot be implemented at the same time due to various constraints. In addition, setting priorities can often be difficult because of the scientific complexity and diverse policy strategies. Although priorities must be science based, they are ultimately policy choices. Section 9.1 provides guidance for the development and implementation of management strategies and actions to recover Oregon's Mid-C steelhead populations. This guidance was adopted by Oregon's Middle Columbia Sounding Board. The characteristics of highest priority actions are identified below. Section 9.1 identifies other high priority actions, though less than highest, as well as other prioritization considerations.

Highest Priority Actions

- Provide long-term protection of habitat conditions and conservation of natural ecological processes that support the viability of priority extant populations and their primary life history strategies throughout their entire life cycle. A population is considered a priority if it is critical for MPG or DPS viability.

- Protect or enhance viability of multiple steelhead populations.

- Support conservation of unique and rare functioning habitats, habitat diversity, life histories and genetic attributes.

- Target the key limiting factors and that contribute the most to closing the gap between current status and desired future status of priority populations.

- Provide critical information needed for assessing success and making adaptive management decisions.

1.10 Management Action Effectiveness

Section 10 presents an analysis of the effects of the proposed actions on the performance of Oregon populations in the Mid-Columbia River steelhead DPS. The analysis was performed in sequential steps, first by projecting outcomes for tributary actions alone, then sequentially adding in hatchery fish genetic effects, then types of out-of-subbasin actions, and finally actions to manage stray hatchery fish. The results at each step provided a means for comparing relative benefits of the proposed actions.

Approach

The analysis of action effectiveness was performed using two modeling platforms, Ecosystem Diagnosis and Treatment (EDT) and the All-H-Analyzer (AHA), that address different types of

limiting factors affecting salmonid population performance during the life cycle. Linking the two models provided a way of projecting benefits measured at the end of the life cycle for a wide range of potential actions, regardless of what life stage an action affects. We made a number of changes to both models to improve the application to our analyses.

Modified EDT Model

The EDT model was used to analyze the potential benefits of tributary habitat actions. The model is designed to estimate salmonid population performance based on characteristics of the aquatic habitat. Four scenarios were modeled using the EDT model, reflecting two priorities for where actions would be implemented at two future times: 1) High priority actions and locations only at 25 years in the future; 2) High priority actions and locations only at 100 years in the future; 3) All actions and locations at 25 years in the future; and 4) All actions and locations at 100 years in the future. In addition, the Deschutes Westside population was modeled with and without passage/reintroduction at the Pelton-Round Butte Complex to illustrate the added benefit of providing passage.

A two-part process was used to determine action effectiveness. Part 1 asked the question: What stream reaches would be affected by each of the actions? This was answered by linking stream reaches in each of the five subbasins to the actions. Part 2 consisted of explicitly defining distinct elements—or factors—that are used to compose the overall effectiveness value applied in the analysis. Five elements of action effectiveness were recognized, each acting as a scalar to determine how effective an action would be in moving an attribute's current baseline rating back toward the undeveloped state: *Effect*, the potential effectiveness of action; *Intensity,* the scale at which an action is to be applied; *Lag,* how much of the potential effectiveness of an action will be achieved at a time in the future (25 or 100 years in the future); *Schedule,* an implementation schedule effect, i.e., whether implementation is delayed to some point in the future, whereby the amount of the potential effectiveness of an action would be reduced at a time in the future; and A*ttribute,* the potential effectiveness of an action due to an attribute effect.

Modified AHA Model

The AHA model linked the analyses of tributary habitat actions to prospective recovery actions involving hatchery fish and the mainstem Columbia River; integrating the effects of various types of actions over the full life cycle. A set of scenarios was modeled using AHA, representing baseline conditions, current conditions, and combinations of actions aimed at tributary habitat, mainstem Columbia River factors, and hatchery fish management. AHA scenarios were run in a stepwise fashion, starting with baseline, then current condition, then adding in actions sequentially, each being added to the previous scenario.

Importantly, the AHA model allowed incorporation of potential effects of hatchery programs on the genetic fitness of the natural populations. The model incorporates key concepts and assumptions about the effects of genetic interactions between hatchery and natural fish built on the work of Lynch and O'Hely (2001) and Ford (2002), with further development of those ideas by geneticists working with the Hatchery Scientific Review Group (HSRG)(Mobrand – Jones & Stokes 2005). Fitness is computed in the model using Ford's (2002) modeling equations. It was used to evaluate potential genetic effects on the natural populations due to interactions between out-of-DPS stray hatchery fish and from the Umatilla supplementation hatchery program.

Several prospective actions to be taken in the mainstem Columbia River were also modeled using AHA, including: predator management – aimed at reducing predation rates caused by terns and northern pikeminnow; downstream juvenile passage improvements – measures to improve survival at each of the mainstem dams; Columbia estuary habitat improvements – measures to enhance habitat conditions within the Columbia estuary; and harvest – regulatory measures to reduce or hold harvest impacts in the mainstem Columbia River to current levels. We used survival improvement estimates provided in the recent BiOp (NOAA Fisheries 2007a) for predation, hydrosystem, and estuary actions. The use of these values in no way implies endorsement of the validity of the estimates or the adequacy of the actions. At this time, these are the only estimates available for the proposed actions.

The output from AHA, also expressed as Beverton-Holt population parameters, represents the expectation for population performance when all actions are integrated together. These parameters were then converted to the percent change in each parameter value compared to baseline conditions and multiplied by the ICTRT's baseline population measures to compute expected ICTRT-equivalent parameter values reflecting the effects of all actions.

Summary of Findings

Overall, analysis results show that population performance, as measured by both productivity and spawner abundance, increases markedly for all populations under the recovery action scenarios.

Results of All-H integration analysis are summarized below for each population and presented in Section 10. Changes in performance measures associated with each action scenario are presented for intrinsic productivity and equilibrium spawner abundance. The results are comparable to population metrics presented in Section 6 for baseline performance, as derived empirically by the ICTRT, and to minimum productivity (at the threshold abundance level) and abundance viability thresholds at the 5% risk level.

Fifteenmile Creek Population
Population performance is increased markedly for all scenario combinations analyzed. By far, the largest contribution to performance improvements results from tributary habitat actions. Relatively small increases are attributable to mainstem actions. Viability thresholds are exceeded for all scenarios.

Deschutes River Eastside Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements result from tributary habitat actions, with greatest benefits accruing for the 100 year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Very substantial benefits to both population productivity and natural-origin spawner abundance also occur as a result of reducing the number of stray hatchery fish spawning with natural-origin fish. Viability thresholds are exceeded for all scenarios.

Deschutes River Westside Population
The largest increases in population performance associated with the range of scenario combinations analyzed occur as a result of decreasing the number of stray hatchery fish and/or by providing passage at the Pelton-Round Butte Complex (includes passage at Whychus Creek barriers). In the absence of the removal of strays or passage, benefits are much reduced. For those scenario combinations lacking removal of strays and passage, beneficial effects of tributary actions are greatest, though beneficial cumulative effects of adding in mainstem actions are clearly evident. The viability threshold for productivity is exceeded for all action scenarios. The minimum abundance threshold was not achieved for any scenario.

Lower Mainstem John Day River Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements result from tributary habitat actions, with greatest benefits accruing for the 100 year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Viability thresholds are exceeded for all scenarios.

North Fork John Day River Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements result from tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Viability thresholds are exceeded for all scenarios.

Middle Fork John Day River Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements result from tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Viability thresholds are exceeded for all scenarios.

South Fork John Day River Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements result from tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. The viability threshold for productivity is exceeded for all action scenarios. The abundance threshold is reached in about 30% of the action scenarios.

Upper Mainstem John Day River Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements result from tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Viability thresholds are exceeded for all scenarios.

Umatilla River Population
Population performance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements results from tributary habitat actions, with greatest benefits accruing for the 100 year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Viability thresholds are exceeded for all scenarios.

Walla Walla River Population
Population performance is increased markedly for all scenario combinations analyzed. Relatively small differences exist between scenario results at 25 and 100 years. The largest contribution to performance improvements is estimated to be due to tributary habitat actions. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions. Viability thresholds are exceeded for all scenarios.

1.11 Time and Cost Estimates

Section 11 summarizes the time and partial costs expected for recovery of Oregon Mid-C steelhead populations. Appendix I discusses the costs of implementing the various actions identified in Section 9 in more detail.

Currently, we estimate the overall total cost for implementation of proposed actions that we were able to estimate for all ten Oregon Mid-C steelhead populations at $512,843,328. This estimate reflects preliminary summary partial costs for recovery of the populations based on implementation of identified management actions, where available information was sufficient to do so. The draft cost estimates (Table I-1) were prepared by a NMFS economist at the Northwest Fisheries Science Center in Seattle using a regional recovery cost database, together with input and review from ODFW, regional experts, and the Mid-Columbia Sounding Board in 2007. The total cost will increase when unit cost estimates, scale of projects, and costs for all actions are determined. Costs for some of the expensive actions like land acquisition, flow enhancement, land leases, and RM&E have yet to be determined.

Estimated costs for different projects range widely from relatively less expensive fish passage projects to more expensive projects, such as restoring stream channel structure and complexity. The Lower John Day ($116,192,806) and Deschutes River Westside ($114,110,501) populations have the most expensive estimated total project costs, while the South Fork John Day ($8,656,103) and Fifteenmile ($28,358,906) populations have the smallest total costs. These total cost differences may be due to many factors such as size of the population, extent to which current conditions need to be improved, scale of projects, number of projects identified, and the availability of recovery action cost information by population at this time.

NMFS estimates that implementation of the recovery actions for the Mid-Columbia steelhead DPS, like recovery for most of the ESA-listed Pacific Northwest salmon and steelhead, could take 50 to 100 years. While this recovery plan contains an extensive list of actions that need to be undertaken to recover Oregon's Mid-Columbia steelhead populations, there are many uncertainties involved in predicting the course of recovery and in estimating total costs. These include uncertainties regarding biological and ecosystem responses to recovery actions, as well

as uncertainties regarding long-term and future funding. Given the uncertainties in developing recovery cost estimates, Oregon is not able to estimate total or 10-year implementation costs to recover Oregon's populations in the Mid-Columbia steelhead DPS. Table I-2 in Appendix I, however, provides current average expenditures on habitat projects expected during the next five-year period. These projected five-year habitat project expenditures total approximately $102 million.

In early 2008, Oregon, NOAA, and other partners will develop a plan for recovery project implementation that will include project cost estimates. The implementation plan will identify what entity or individual will carry out the recovery actions and the timeline for implementation. Recovery costs will be revised in the future as specific project budgets are completed.

1.12 Implementation Plan and Adaptive Management Framework

The successful implementation of the Oregon Mid-Columbia Steelhead Conservation and Recovery Plan recovery actions, research, monitoring and evaluation, and adaptive management process will require significant funds and the coordinated work of ODFW, State agencies, tribes, counties, irrigation districts, agriculture and private forest land managers, NMFS, U.S. Forest Service, BLM, other Federal agencies, local residents, citizen groups, utilities, other agencies, and individuals. ODFW, in coordination with the Oregon Governor's Office and NMFS, has taken the lead in developing this recovery plan; all will continue to be instrumental in its implementation.

Oregon's recovery plan implementation framework is intended to provide a collaborative approach to implementation, science guidance and policy direction, as well as facilitate information exchange and coordination from local-level action entities to upper level decision makers and provide linkage to state, DPS and regional forums. Existing forums, groups, partnerships and involved citizens make this implementation structure possible, but additional resources and funding will be needed to make it work effectively and successfully. The basic components of Oregon's implementation framework include a Recovery Team, an Implementation Coordinator, an Implementation Team, a Technical Team, and Watershed Teams. These teams will interface with and potentially strengthen the various state agency teams associated with the Oregon Plan for Salmon and Watersheds that provide for policy, management, and monitoring of interagency Oregon Plan programs for the conservation and restoration of habitat, water quality, and salmon. In addition, these teams will function to coordinate within the DPS implementation and adaptive management framework. The implementation framework will adapt and change as necessary to adjust to funding, available resources, and implementation needs.

Mid-C steelhead have a complex life cycle that traverses habitats from high elevation tributaries to the open ocean. Life history strategies and life stage specific habitat requirements are complex. There are many limiting factors and threats that influence the viability of Oregon's Mid-C steelhead at all life stages. The suite of proposed management actions to address primary limiting factors and threats across the entire life cycle is extensive and diverse. Although the limiting factors and threats, as well as the management actions, have been developed based on the best available science, there remains considerable uncertainty regarding the outcomes and

effectiveness of the proposed management actions as well as the status of the populations. It is this uncertainty which generates the essential need for an effective adaptive management process.

A successful adaptive management process requires that we understand how and why steelhead and their associated habitats respond to the management actions we take to address key limiting factors and threats. In addition, success requires a decision framework and process which considers new information in the development and implementation of future management actions.

One of the great challenges facing the development and implementation of an effective adaptive management strategy for Oregon's Mid-C steelhead is the extensive number of organizations that implement management actions, as well as the complexity in jurisdictional and management decision authority. There are many different organizations including state agencies, tribes, counties, irrigation districts, agriculture and private forest land managers, NOAA, U.S. Forest Service, BLM, other federal agencies, local residents, citizen groups, utilities and others that implement management actions.

Along with this implementation complexity is a parallel level of jurisdictional, management decision authority, and process complexity. There is no one single decision body that holds decision authority for management actions across all the H's. Decision authority for management actions resides across many entities including state, tribal, federal, county as well as others. Those diverse decision frameworks and processes, many independent of others, create coordination and collaboration challenges. We acknowledge that it is unreasonable to expect centralization and integration of all authorities and decision processes into a single decision framework. Our approach is to develop a collaboration and coordination process that uses the implementation structures and allows for sharing of information and decisions that influence recovery of Mid-C steelhead.

1.13 Research, Monitoring, and Evaluation

Section 13 presents a detailed monitoring and evaluation (M&E) plan that covers the Oregon portion of the Mid-C steelhead DPS. It describes the types of monitoring approaches that are used, current efforts underway, and additional M&E recommended for assessing the status and trends in population viability and for evaluating the success of management actions implemented to recover these steelhead populations. Logistical and monetary limitations are understood to exist; however, a comprehensive M&E plan should help to focus efforts towards the common goal of assessing success in population and DPS recovery.

The M&E plan is based in part on principles and concepts laid out in the NMFS guidance document, *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance (May 1, 2007)* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf. It also borrows from RM&E plans that were developed for Mid-Columbia subbasins and other Columbia Basin regions.

The plan also follows the principles of adaptive management, the process of adjusting management actions and/or directions based on new information. Adaptive management is considered crucial for salmonid recovery programs because of the length and complexity of the salmonid life cycle, and the uncertainties involved in improving salmonid survival and status. The plan addresses adaptive management by linking monitoring and evaluation to biological and physical responses, and using these results to better design and implement of management actions.

Types of Monitoring Programs

Several types of monitoring are needed to support adaptive management and to allow managers to make sound decisions:

- **Status and Trends Monitoring.** Status monitoring includes measures of the current state or condition of the population at any given time. Trend monitoring tracks these conditions to provide a measure of the increasing, decreasing, or steady state of a status measure through time. Status and trends monitoring includes the collection of standardized basic information used to monitor broad-scale trends over time in the status of fish populations, habitat conditions, and other ecosystem factors affecting fish. This information is the basis for evaluating the cumulative effects of management actions on fish and the aquatic and terrestrial ecosystem.

- **Action Effectiveness Monitoring.** Action effectiveness monitoring involves project-scale monitoring of local conditions to determine if implemented actions were effective in creating the desired proximate change. Action effectiveness monitoring typically is used to determine whether project- or program-specific goals were met. This type of monitoring also includes post-project monitoring to see whether the actions continue to function as they were designed or intended. Note that status and trend monitoring may be appropriate for fulfilling these needs but that project effectiveness monitoring generally requires focused evaluations of more specific parameters directly associated with actions. Specific indicators and metrics need to be developed in plans for each category of action. Specific plans will include measurable variables or parameters to address each objective, study design (spatial and temporal scale, tests and controls, statistical criteria, etc.), data collection methods and reference examples, and analyses and decisions in response to results.

- **Implementation and Compliance Monitoring.** Implementation and compliance monitoring involves monitoring of management actions to determine if they were implemented as planned and meet established benchmarks. This monitoring is typically conducted by the groups implementing the management and restoration actions.

- **Uncertainties Research.** Uncertainties research includes scientific investigations of critical assumptions and unknowns that constrain effective recovery plan implementation. Uncertainties include unavailable pieces of information required for informed decision making as well as studies to establish or verify cause-and-effect and identification and analysis of limiting factors.

Population-Specific Research, Monitoring, and Evaluation Needs

The plan addresses each major population group separately. In some cases, specific objectives are provided at the population scale to characterize unique monitoring needs. Specific approaches are presented that address each objective. A brief sampling design, including the spatial and temporal scale of application, is provided for each objective. Measurement variables protocols and a description of the analysis are presented. Existing and potential funding sources are identified and finally, implementation and coordination details are discussed. The techniques described for each population are not necessarily exhaustive, but are meant to be representative of those actions considered to have potential while recognizing logistical and monetary constraints.

In general, population research, monitoring and evaluation activities are designed to gain information needed to improve knowledge of population viability. They examine status and trends in abundance and productivity of natural spawners; status of spatial structure based on current and historically utilized habitat; status and trend in condition of current and historically utilized habitat; freshwater and full life cycle productivity, and primary factors limiting freshwater production; current status, and change in future status of population life history and phenotypic diversity; effect of disease and predation on population abundance, productivity, diversity, and distribution; effect of harvest on population abundance, productivity, and diversity; effect of hydropower on population abundance, productivity, diversity, and distribution; and effect of habitat degradation and habitat restoration activities on population abundance, productivity, and distribution.

Following are specific research, monitoring and evaluation needs for each population in addition to the general types of activities described above:

Fifteenmile Creek population

- Improved estimates of abundance of stray hatchery fish
- Determine life history characteristics

Deschutes River Eastside and Westside populations

- Effectiveness of passage at Pelton-Round Butte Complex
- Effectiveness of reintroduction into Whychus Creek and the Crooked River population
- Extent of mainstem spawning
- Impact of Snake River strays on viability
- Fall back rate of natural and hatchery fish that pass Sherars Falls
- Spawning distribution of hatchery-origin strays
- Genetic characteristics of natural populations and the degree of introgression of hatchery strays
- Steelhead-resident rainbow relationship in Westside population and impact on steelhead capacity

Crooked River population

- Assess the success of restoring natural production within the Crooked River population boundaries

John Day River populations

- Improved estimates of abundance of hatchery-origin strays
- Spawning distribution of hatchery-origin strays

Umatilla River population

- Hatchery supplementation effectiveness
- Relative reproductive success of hatchery fish
- Spawning distribution of hatchery-origin fish
- Effectiveness of major flow enhancement actions (Phase 3)

Walla Walla River population

- Improved estimates of abundance of hatchery-origin strays
- Spawning distribution of hatchery-origin strays
- Proportion of population spawning below Nursery Bridge
- Effectiveness of major flow enhancement and passage improvement actions

Out of Basin Research, Monitoring and Evaluation Needs

The following types of RM&E actions are needed to support assessment of recovery of the Mid-C steelhead DPS and its Oregon populations:

- Survival improvements from hydrosystem actions
- Survival improvements from predator control actions
- Survival improvements from estuary actions
- Population specific mainstem harvest rates
- Marine survival estimates and variation through time
- Influence of transportation on Snake River hatchery steelhead straying

1.14 Population Summaries

Tables 1-6 through 1-16 summarize vital information related to the recovery of each of Oregon's ten Mid-C steelhead populations. For each population, the summaries identify: key population attributes, minimum viability levels for a low risk recovery scenario, viability assessment results, the viability gap, major limiting factors and threats, and the highest priority tributary habitat strategies and actions.

Table 1-6. Summary of Recovery Information for Fifteenmile Creek Population.

Key Population Attributes
The population occupies the entire Fifteenmile Subbasin and several smaller subbasins—including the Rock, Mosier, Chenoweth, Mill, and Threemile watersheds—which enter the Columbia River directly downstream from Fifteenmile Creek. Current spawning distribution is similar to historical with major production areas in Fifteenmile, Ramsey, Eightmile, and Fivemile creeks.
Recent year natural spawners include only natural-origin fish. Hatchery strays in the Fifteenmile Creek population have rarely been documented.
The population contains three MaSAs, all located in the Fifteenmile Creek watershed: Upper Fifteenmile, Eightmile and Fivemile. It also contains five MiSAs: Mill, Chenoweth, Threemile, Mosier and Lower Fifteenmile.
It is the only Mid-C steelhead population that is classified as an entirely winter run life history type. It is part of the Cascade Eastern Slope Tributaries MPG.
The population is considered a Basic size population with a mean minimum abundance threshold of 500 spawners.
Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)
Abundance: Minimum abundance threshold of 500 spawners.
Productivity: Minimum productivity level of 1.56 recruits per spawner at the threshold abundance.
Viability Assessment Results
Abundance/Productivity: Population is at low risk based on current abundance and productivity. The Abundance/Productivity point estimate resides above the 1% risk curve, but the population is not considered to be at very low risk because of uncertainty criteria, the 98% confidence interval (CI) extends below the 25% risk curve. These A/P results should be viewed with caution, as abundance and productivity estimates for the Fifteenmile population are based on 15 years of spawner/recruit data.
Spatial Structure/Diversity: The integrated SS/D rating is low risk for the population. There has been little change in distribution relative to the historical distribution. The absence of major reductions in distribution resulted in a rating of very low risk for spatial structure metrics. There have likely been minor reductions in life history diversity and phenotypic variation, but these changes are not severe enough to raise risk levels to moderate. There are few hatchery fish in the population resulting in low risk for spawner composition.
Overall Viability Rating: Population *currently meets viability criteria* because both A/P and SS/D are rated at low risk. A relatively small increase in productivity is required to move this population into "highly viable" status. Monitoring should be continued to allow analysis of a longer data time series.
Viability Gap
Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 703 exceeds the minimum threshold abundance of 500. The current productivity estimate of 1.82 recruits per spawner resides between the 5% and 1% risk curves. There is no observed gap or uncertainty gap for the 5% risk level. The observed and uncertainty gaps for the 1% risk level are 0.03 and 0.09 respectively.
Spatial Structure/Diversity: There are no gaps for SS/D since all the SS/D metrics rated very low or low risk.
Limiting Factors and Threats
Primary Limiting Factors: Tributary Habitat: low flows, high water temperatures, degraded riparian condition, sediment routing, degraded floodplain, degraded channel structure (channel confinement and overall habitat diversity); *Hydro:* mainstem passage.
Primary Threats: Current land use practices (including roads, residential development, and agricultural and forest practices) and the Columbia River mainstem hydrosystem.
Primary Life Stages Affected: Fry, summer parr, winter parr, smolts.
VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.
Tributary Management Strategies and Actions (Highest Priority)
Habitat Strategies
Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs.
Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water

conservation measures, improve irrigation conveyance and efficiency.

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, riparian fencing.

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, and stabilize streambanks.

High Priority Areas for all strategies: Fifteenmile Cr - Mouth to FS boundary; Ramsey Cr - Mouth to new FS boundary; Eightmile Cr - Hwy 197 to FS boundary; Fivemile Cr - Mouth to FS boundary.

Harvest Strategies

Strategy: Manage harvest to maintain current low impact fisheries. *Key actions:* Maintain current low impact fisheries.

Hatchery Strategies

Strategy: Reduce uncertainty in abundance and proportion of stray hatchery fish spawning naturally. *Key actions*: increased monitoring of hatchery fish on spawning grounds.

Table 1-7. Summary of Recovery Information for Deschutes River Eastside Population.

Key Population Attributes
The Deschutes River Eastside population occupies the Deschutes River from its mouth to Trout Creek and all tributaries flowing in from the east side, including Willow Creek above Pelton Dam.
Spawners in the population include natural-origin returns, hatchery returns from Deschutes River-origin fish produced at Round Butte Hatchery and out-of-DPS hatchery strays primarily from the Snake River Basin. Hatchery-origin fish comprise a significant proportion of the natural spawners.
The population contains six MaSAs: Buck Hollow, Bakeoven, Ward/Antelope/Cold, Lower Trout, Upper Trout and Willow. It contains two MiSAs: Jones Canyon and Campbell.
The population exhibits a summer life history strategy and is part of the Cascade Eastern Slope Tributaries MPG.
The ICTRT considers it an Intermediate population with a mean minimum abundance threshold of 1,000 spawners.
Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)
Abundance: Minimum abundance threshold of 1,000 spawners.
Productivity: Minimum productivity level of 1.35 recruits per spawner at the threshold abundance.
Viability Assessment Results
Abundance/Productivity: The population is at low risk based on current abundance and productivity. The point estimate on the viability curve resides above the 1% curve, but the population is not considered to be at very low risk since the 99% CI extends below the 25% risk curve.
Spatial Structure/Diversity: The integrated SS/D rating is moderate risk for the population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was low risk. However, the population's spawning distribution is reduced from the historical distribution, primarily from loss of spawning in the Willow Creek drainage. The population remains broadly distributed with little changes in gaps and good continuity within the current accessible habitat. The rating for Goal B "maintaining natural levels of variation" was moderate risk. Habitat changes in key tributary production areas have likely resulted in limitations to life history diversity and reduction in phenotypic expression. Also, a significant proportion of natural spawners are out-of-DPS strays which resulted in a high risk rating for spawner composition.
Overall Viability Rating: The Deschutes River Eastside population *currently meets the recommendation for viable status.* The SS/D rating is moderate risk primarily because of the influence of habitat changes on life history and phenotypic expression, as well as out-of-DPS hatchery spawners.
Viability Gap
Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 1,599 substantially exceeds the minimum threshold abundance of 1,000. The current productivity estimate of 1.89 resides in the very low risk zone and thus there are no observed abundance/productivity gaps. The lower end of the productivity 99% confidence interval is below the 25% risk curve resulting in a 0.05 gap to meet uncertainty criteria for 1% risk level. The abundance/productivity dataset is a relatively short time series which results in a larger 90% CI than is typical of most other Oregon Mid-C populations.

Spatial Structure/Diversity: Spatial structure/diversity gaps were identified for the following metrics: *Phenotypic variation*: moderate risk due to likely reduction in juvenile and adult migration patterns resulting from flow and temperature changes in tributary production areas; *Spawner composition*: Out-of-DPS spawners rated high risk due to the high proportion of Snake River strays spawning naturally in the population. Out-of-population within MPG spawners rated moderate risk due to the proportion of Round Butte Hatchery fish spawning naturally in the population.
Limiting Factors and Threats *Primary Limiting Factors: Tributary Habitat:* degraded riparian condition, low flows, high water temperatures, degraded channel structure/complexity and floodplain connectivity, impaired fish passage. *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage. *Primary Threats:* Hatchery production which results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (grazing, roads, residences, forestry and agricultural practices that simplify habitats and irrigation withdrawals); the Columbia River mainstem hydrosystem. *Primary Life Stages Affected:* Spawners, fry, summer parr, winter parr, smolts. *VSP Characteristics Impacted:* Abundance, productivity, spatial structure, diversity.
Tributary Management Strategies and Actions (Highest Priority) *Habitat Strategies* *Strategy:* Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: Bakeoven Cr (mouth to Deep Cr), Buck Hollow Cr (mouth to Macken Canyon), Trout Cr (Little Trout Cr. to headwaters) *Strategy*: Restore passage and connectivity. *Key actions*: Remove/replace barriers, adequate screening of irrigation diversions. *Priority areas*: Bakeoven Cr, Mud Springs Cr., Hay Cr *Strategy*: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures, improve irrigation conveyance and efficiency. *Priority areas:* Trout Cr (mouth to Clover Cr), Antelope Cr *Strategy:* Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Trout Cr (Little Trout Cr to Clover Cr, sections from mouth to Antelope Cr), Antelope Cr, Hay Cr *Strategy:* Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, and stabilize streambanks. *Priority areas*: same as for riparian strategy. *Hydrosystem Strategies* *Strategy:* Improve flow patterns through Pelton-Round Butte Complex (PRBC), restore water quality below PRBC. *Priority areas*: Deschutes R. (at and below PRBC). *Harvest Strategies* *Strategy:* Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries. *Hatchery Strategies* *Strategy:* Reduce uncertainty regarding hatchery strays and reduce abundance and proportion of stray hatchery fish spawning naturally. *Key actions*: coded-wire-tagging program, development of alternative broodstocks for programs contributing strays, increased monitoring on spawning grounds and trap and removal of strays.

Table 1-8. Summary of Recovery Information for Deschutes River Westside Population.

Key Population Attributes The Deschutes River Westside population occupies the mainstem Deschutes River from Trout Creek to the Pelton-Round Butte Complex (PRBC) at RM 100 and tributaries joining the Deschutes from the Westside, including the Warm Springs River and Shitike Creek below the hydroelectric complex and the Metolius River and Whychus Creek drainages above the complex. The Warm Springs watershed and Shitike Creek currently provide most spawning habitat. Whychus Creek was once a major steelhead producer for the population. Recent year natural spawners include returns originating from naturally spawning parents, strays from the Deschutes Subbasin Round Butte Hatchery program, and a significant number of out-of-DPS hatchery strays from the Snake

River. Natural-origin spawners have comprised an average of 82% of natural spawning fish since 1978.

The population contains six MaSAs: Upper Warm Springs, Whychus, Upper Metolius, Mill, Beaver and Shitike; and nine MiSAs.

The population exhibits a summer life history strategy and is part of the Cascades Eastern Slope Tributaries MPG.

The ICTRT considers it a 'large' population with a mean minimum abundance threshold of 1,500 spawners. Access to a considerable amount of historical habitat is blocked by PRBC, with current spawning only below the barrier. The minimum abundance threshold is 1,000 spawners for currently available habitat.

Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)

Abundance: Minimum abundance threshold of 1,500 spawners (1,000 for currently accessible habitat).

Productivity: Minimum productivity level of 1.35 recruits per spawner at the threshold level.

Viability Assessment Results

Abundance/Productivity: Population is at high risk based on current abundance and productivity. The point estimate on the viability curve resides below the 25% risk curve.

Spatial Structure/Diversity: The integrated spatial structure/diversity rating is high risk for the population. It rates at moderate risk for two of the spatial distribution metrics because the current distribution is substantially reduced from the historical intrinsic distribution due to blocked passages to areas above the Pelton-Round Butte Complex. Ratings for two metrics related to Goal B "maintaining natural patterns of variation" resulted in a moderate rating for Goal B and the overall moderate rating. Genetic variation rated moderate due to limited data and the lack of differentiation between the Deschutes samples and outside-basin hatchery samples. Samples collected in 2005-2007 will better inform the risk associated with genetic variation. The proportion of out-of-DPS hatchery strays resulted in a high risk rating for spawner composition. Most of these strays originate from the Snake River Basin.

Overall Viability Rating: The Deschutes River Westside *population does not currently meet recommendations for viability and is below maintained status*. However, it is the only extant Large or Very Large population in the MPG and should be recovered to meet the viability criteria. A substantial increase in productivity will be required to raise the A/P values to the low risk level. Genetics information presently being collected will better inform the genetics variation risk level in the future. A reduction in the out-of-ESU hatchery stray proportion will be needed to reduce the risk rating for the spawner composition metric.

Viability Gap

Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 456 is well below the abundance threshold of 1,000, the threshold abundance for currently available habitat. The current productivity estimate of 1.05 recruits per spawner is well below the minimum of 1.35 required at the threshold abundance. The observed gaps, which are greater than uncertainty gaps, for the 5% and 1% risk levels are 0.78 and 0.92 respectively. This gap is by far the largest observed gap of all the Oregon Mid-C populations. The large gap results from the substantial difference in the equilibrium abundance (448) and the threshold abundance, as well as the low productivity.

Spatial Structure/Diversity: Spatial structure/diversity gaps were identified for the following metrics: *Spatial extent and range of population*: moderate risk because spawner distribution is substantially reduced from historical due to blocked access to Whychus Creek and the Metolius River; *Genetic variation:* moderate risk because there are limited genetics data available and the samples that have been analyzed show similarity to out-of-DPS hatchery strays; *Spawner composition: O*ut-of-DPS spawners rated high risk because out-of-DPS strays have comprised a significant proportion of the natural spawners in this population for many generations.

Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: degraded channel structure and complexity, altered sediment routing, high water temperature, low flows and lack of fish passage over PRBC; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage and tributary passage to blocked areas above Pelton-Round Butte Complex.

Primary Threats: Hatchery production that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (grazing, roads, residences, forestry and agricultural practices that simplify habitats and irrigation withdrawals); the Columbia River mainstem hydrosystem, Pelton-Round Butte Complex.

Primary Life Stages Affected: Spawners, fry, summer parr, winter parr, smolts.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

Tributary Management Strategies and Actions (Highest Priority)
Habitat Strategies
Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas:* Spawning areas in mainstem Deschutes R. below PRBC.
Strategy: Restore passage and connectivity. *Key actions*: Restore passage at PRBC, remove/replace barriers, adequate screening of irrigation diversions. *Priority areas*: Deschutes R. (RM 100), Warm Springs R, Shitike Cr, Beaver Cr.
Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures, improve irrigation conveyance and efficiency. *Priority areas:* Whychus Cr.
Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Deschutes R. (Eagle Cr to Shitike Cr), Deschutes R (Trout Cr to PBR), Warm Springs R., Shitike Cr., Beaver Cr., Whychus Cr.
Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, and stabilize streambanks. *Priority areas*: Deschutes R. (Eagle Cr to Shitike Cr), Deschutes R. (Trout Cr to PBRC), Warm Springs R. (mouth to Badger Cr), Shitike Cr. (mouth to road crossing), Beaver Cr. (mouth to Robinson Park Bridge)
Hydrosystem Strategies
Strategy: Restore steelhead production in historical habitats. *Key actions*: develop juvenile collection and passage through PRBC, improve flow patterns through PRBC, restore water quality below PRBC. *Priority areas*: Deschutes R. (at and below PRBC).
Harvest Strategies
Strategy: Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries.
Hatchery Strategies
Strategy: Reduce uncertainty regarding hatchery strays and reduce abundance and proportion of stray hatchery fish spawning naturally. *Key actions:* coded-wire-tagging program, development of alternative broodstocks, increased monitoring on spawning grounds and trap and removal of strays.
Strategy: Reduce genetic risks associated with Round Butte Hatchery Program. *Key actions*: investigate incorporating naturally produced local steelhead into RBH broodstock.
Strategy: Restore natural production in historically utilized habitats. Key actions: develop plan for steelhead reintroductions above PRBC. *Priority areas*: Metolius R, Whychus Cr, Deschutes R.

Table 1-9. Summary of Recovery Information for Deschutes/Crooked River Population.

Key Population Attributes
The Deschutes/Crooked River population once occupied the Crooked River drainage, a major watershed in the Deschutes basin.
The population is now extinct because of the lack of passage above Pelton Dam.
The population exhibited a summer life history strategy and is part of the Cascade Eastern Slope Tributaries MPG.
The ICTRT considers it a very large population with a mean minimum abundance threshold of 2,250 spawners.
Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)
Abundance: Minimum abundance threshold of 2,250 spawners.
Productivity: Minimum productivity level of 1.19 recruits per spawner at the threshold abundance.
Viability Assessment Results
The ICTRT did not complete a viability assessment for the population because it is currently extinct.
Overall Viability Rating: The Deschutes/Crooked River population is currently considered extinct.
Viability Gap
A gaps analysis was not completed for the Deschutes/Crooked River population because it is currently extinct.
Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: degraded channel structure and complexity and floodplain connectivity, degraded riparian condition, high water temperature, low flows, altered hydrology sediment routing, and lack of fish passage; *Hydro:* Impaired upstream and downstream migration.

Primary Threats: grazing and agricultural practices, urban development, off highway vehicle (OHV) use, irrigation withdrawal, dams, lack of floodplain connectivity; Pelton-Round Butte Complex on the mainstem Deschutes blocks fish passage.

Primary Life Stages Affected: All life stages.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

Tributary Management Strategies and Actions (Highest Priority)

Habitat Strategies

Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: Crooked River (RM 6-14, RM 55-70), McKay Cr, Ochoco Cr (below Ochoco Dam)

Strategy: Restore passage and connectivity. *Key actions*: Remove/replace barriers including dams, road culverts, irrigation structures, infiltration galleries; provide adequate screening of irrigation diversions. *Priority areas*: Rice Baldwin Dam, Stearns Dam, Seamus Dam, Parga Dam, Peoples irrigation diversion

Strategy: Restore floodplain connectivity and function. *Key actions*: Reconnect floodplain and side channels to channel. *Priority areas:* Crooked River (RM 31-51), McKay Cr

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures, improve irrigation conveyance and efficiency, lease/purchase water rights and convert to instream. *Priority areas:* Crooked River (RM 14-55), McKay Cr, Allen Cr, Ochoco Cr (below Ochoco Dam)

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Crooked River (RM 14-55), McKay Cr, Ochoco Cr (below Ochoco Dam), Allen Cr

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, and stabilize streambanks. *Priority areas*: Crooked River (RM 31-51), McKay Cr.

Hydrosystem Strategies

Strategy: Restore steelhead production in historical habitats. *Key actions*: develop juvenile collection and passage through PRBC, improve flow patterns through PRBC, restore water quality below PRBC. *Priority areas*: Deschutes R. (at and below PRBC).

Hatchery Strategies

Strategy: Restore natural production to blocked areas above PRBC. *Key actions*: Develop and implement a comprehensive plan for the reintroduction of steelhead into the Crooked River population area.

Table 1-10. Summary of Recovery Information for Lower Mainstem John Day River Population.

Key Population Attributes

The population occupies the Lower John Day watershed below the mouth of the South Fork John Day River and the town of Dayville. Steelhead in this population spawn in tributary streams connected to the lower John Day River including Bridge, Butte, Thirtymile, Hay and Rock creeks.

Recent year natural spawners include returns originating from naturally spawning parents, and a small fraction of strays from the Snake River and Columbia River hatchery programs.

The population contains 11 MaSAs and 19 MiSAs. Major spawning areas include Bridge, Mountain, Cottonwood, Hay, Middle Rock, Upper Rock, Pine Hollow, Long Rock (Lower John Day) Thirtymile, Butte, and Grass Valley. All 11 MaSAs are currently occupied and 11 of the 19 MiSAs are occupied.

The population exhibits a summer life history strategy and is part of the John Day River MPG.

It is considered a Very Large population with a mean minimum abundance threshold of 2,250 spawners.

Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)

Abundance: Minimum abundance threshold of 2,250 spawners.

Productivity: Minimum productivity level of 1.19 recruits per spawner at the threshold abundance.

Viability Assessment Results

Abundance/Productivity: The population is at moderate risk based on current A/P. The productivity is very low risk because the point estimate is above very low risk and the lower end of the adjusted standard error is above the 5% risk level. The abundance is moderate risk because it resides between the 5% and 25% risk levels.

Spatial Structure/Diversity: The integrated rating is moderate risk for the population. The rating for Goal A "allowing natural rates and level of spatially mediated processes" was very low. The current spawner distribution is similar to historical with all MaSAs occupied. The MiSAs that are currently unoccupied have little influence on gaps and continuity, and spawners are spread over a very broad geographic area. The rating for Goal B "maintaining natural levels of variation" was moderate risk. This rating was a result of moderate risk for life history and genetic variation and high risk for spawner composition out-of-DPS hatchery strays. The magnitude and trend in out-of-DPS hatchery strays are of significant concern. Analysis of genetics information will yield considerable insight into the genetic variation and characteristics of this population.

Overall Viability Rating: The Lower Mainstem John Day River population *does not currently meet recommendations for viability*, although it does meet criteria for a "maintained" population. To achieve a viable rating, this population must improve in both A/P and SS/D. Out-of-DPS origin spawners are the most influential factor on diversity risk. Additional population specific data are needed to better quantify the spawner composition in this population to reduce the uncertainty associated with this risk metric.

Viability Gap

Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 1,800 is 72% of the threshold abundance of 2,250 natural spawners. The current productivity of 2.99 recruits per spawner is well above the minimum required to meet the 1% risk level. The lower end of the 99% CI also resides above the minimum needed to meet the 1% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.11. This gap is a result of the difference in the equilibrium abundance (2,019) and the threshold abundance.

Spatial Structure/Diversity: Gaps were identified for the following spatial structure/diversity metrics: *Major life history strategies:* moderate risk because habitat changes have resulted in reduced juvenile life history diversity and restricted summer rearing distribution. *Genetic variation*: moderate risk because there are no genetics data and due to potential genetic effects of the high proportion of out-of-DPS spawners. *Spawner composition:* Out-of-DPS spawners rated high risk due to high proportion and increasing trend of out-of-DPS spawners.

Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: degraded channel structure and complexity (habitat quantity and diversity), altered sediment routing, water temperature, and altered hydrology. Impaired fish passage is also a high priority limiting factor in Bridge, Butte, Kahler, Muddy, Rock, and Thirtymile creeks. *Hatchery*: effects of naturally spawning stray hatchery fish on viability. *Hydro:* mainstem passage.

Primary Threats: Hatchery production that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (agricultural and grazing practices, removal of overstory trees and bank vegetation from the riparian corridor, water withdrawals, wetland draining and conversion, and stream channelization and diking; the Columbia River mainstem hydro system.

Primary Life Stages Affected: Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, smolts.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

Tributary Management Strategies and Actions (Highest Priority)

Habitat Strategies

Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: Pine, Bridge, Cottonwood creeks.

Strategy: Restore passage and connectivity. *Key actions*: Remove/replace barriers, adequate screening of irrigation diversions. *Priority areas*: Rock, Upper Rock, Middle Rock, Lone Rock, Thirtymile, Butte, and Bridge creeks.

Strategy Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, stabilize streambanks. *Priority areas*: Rock, Middle Rock, Thirtymile and Butte creeks.

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water

conservation measures, improve irrigation conveyance and efficiency. *Priority areas:* Rock, Bridge, Rock Mountain, lower Parrish and Kahler creeks

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas:* Lone Rock, Mountain Cr (Wheeler Co), Parrish Cr, Cherry Cr, Kahler Cr, Bridge Cr, Thirtymile Cr, Butte Cr, and upper reaches of Pine Hollow Canyon Cr.

Strategy: Restore passage and connectivity: *Key actions:* Remove or minimize use of push up dams; remove or replace barriers blocking passage; provide screening at all irrigation diversions; replace screens that do not meet criteria. *Priority areas*: Rock, Upper Rock, Middle Rock, Lone Rock, Thirtymile, Butte, and Bridge creeks.

Harvest Strategies

Strategy: Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries.

Strategy: Reduce catch and release mortality on natural steelhead spawner. *Key actions*: voluntary curtailment of fishing at higher water temperatures.

Strategy: Improve quality of harvest information. *Key actions*: expand creel surveys.

Hatchery Strategies

Strategy: Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* coded-wire-tagging program, development of alternative broodstocks.

Strategy: Reduce uncertainty in abundance and proportion of stray hatchery fish spawning naturally. *Key actions:* increased monitoring on spawning grounds and possibly trapping.

Table 1-11. Summary of Recovery Information for North Fork John Day River Population.

Key Population Attributes

The population occupies the North Fork John Day watershed excluding the Middle Fork drainage. The North Fork John Day is the largest tributary to the John Day River, draining approximately 1,800 mi^2.

Recent year natural spawners include returns originating from naturally spawning parents, and a small fraction of strays from the Snake and Columbia River hatchery programs.

The population contains 8 MaSAs (Lower North Fork John Day, Potamus, Big Wall, Big, Upper North Fork John Day, Desolation, Granite, and Owens) and seven MiSAs (Bridge, Meadow Brook, two Cabins, Fivemile, Meadow and Ditch).

The population exhibits a summer life history strategy and is part of the John Day River MPG.

The population is considered a Large population with a mean minimum abundance threshold of 1,500 spawners.

Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)

Abundance: Minimum abundance threshold of 1,500 spawners.

Productivity: Minimum productivity level of 1.26 recruits per spawner at the threshold abundance.

Viability Assessment Results

Abundance/Productivity: The North Fork John Day River population is at very low risk based on current abundance and productivity. The point estimate for abundance and productivity resides above the 1% risk curve and the 99% confidence interval for productivity is above the 25% risk curve.

Spatial Structure/Diversity: The combined integrated SS/D rating is low risk for the population. The rating for Goal A "allowing natural rates and level of spatially mediated processes" was very low. Current spawner distribution mimics the intrinsic distribution. The population is distributed broadly across the landscape in numerous MaSAs and MiSAs. Good continuity exists between spawning areas and current gaps between spawning areas are similar to historical gaps. The rating for Goal B "maintaining natural levels of variation" was low risk. However, there remains considerable uncertainty about the ratings for genetic variation and out-of-DPS hatchery strays in the natural spawners. Additional genetic analyses and interpretation is needed to determine if the genetic variation is similar to historical conditions and to examine evidence for degree of stray hatchery fish introgression. The metric for out-of-DPS hatchery strays rated very high. The data used for this rating are a composite from four John Day populations. Additional population specific spawner composition data are needed to improve the certainty of the out-of-DPS stray hatchery risk rating. If there is

significant hatchery introgression that is affecting the genetic variation through time then the risk rating for "genetic variation" will increase and the overall risk rating for Goal B and SS/D will also increase.

Overall Viability Rating: The overall viability rating for the North Fork John Day steelhead population *is considered highly viable* as a result of the A/P rating of very low risk, and the SS/D rating of low risk. There remains considerable uncertainty regarding the genetic effect of out-of-DPS strays, as well as the actual proportion of natural spawners that are hatchery strays. Enhanced monitoring efforts should be undertaken to develop better estimates of the composition of North Fork John Day spawners.

Viability Gap

Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 1,740 exceeds the threshold abundance of 1,500. The current productivity of 2.41 recruits per spawner is well above the value needed to meet the 1% risk level. The lower end of the 90% CI resides above the 1% risk level. No abundance/productivity gaps exist for the 5% or 1% risk levels.

Spatial Structure/Diversity: All metrics rated very low or low risk except for the following: *Spawner composition:* Out-of-DPS spawners rated high risk due to the high estimated proportion of Snake River hatchery strays within this population. There is also considerable uncertainty regarding the hatchery fraction estimates for this population.

Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: degraded floodplain connectivity and function, degraded channel structure and complexity (key habitat quantity, habitat diversity, channel stability), altered sediment routing, water temperature, and low flows; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.

Primary Threats: Hatchery management that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, irrigation withdrawals, mining and dredging); the Columbia River mainstem hydro system.

Primary Life Stages Affected: Parr-to-smolt survival, egg-to-fry survival, smolts.

VSP Characteristics Impacted: Abundance, productivity, diversity.

Tributary Management Strategies and Actions (Highest Priority)

Habitat Strategies

Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: tributaries within the NF John Day Wilderness, NF John Day River (Big Cr to headwaters), SF Desolation Cr, upper Clear Cr

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Cottonwood Cr below Fox Cr, Camas Cr above Wilkins Cr

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, stabilize streambanks. *Priority areas*: Camas Cr (Wilkins Cr to Cable Cr), Clear Cr below Ruby Cr, Olive Cr below Beaver Cr, Bull Run Cr, Cottonwood Cr below EF Cottonwood

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures; improve irrigation conveyance and efficiency. *Priority areas:* Cottonwood/Fox, Rudio, Camas Cr above Wilkins Cr

Harvest Strategies

Strategy: Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries.

Strategy: Reduce catch and release mortality on natural steelhead spawner. *Key actions*: voluntary curtailment of fishing at higher water temperatures.

Strategy: Improve quality of harvest information. *Key actions*: expand creel surveys.

Hatchery Strategies

Strategy: Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* coded-wire-tagging program, marking of all hatchery steelhead in Columbia River Basin, development of alternative broodstocks, reduced transport of hatchery smolts from Snake River.

Strategy: Reduce uncertainty in abundance and proportion of stray hatchery fish spawning naturally. *Key actions:* increased monitoring on spawning grounds and possibly trapping.

Table 1-12. Summary of Recovery Information for Middle Fork John Day River Population.

Key Population Attributes
The population occupies the Middle Fork drainage, which contains five watersheds, all used by steelhead.
Recent year natural spawners include returns originating from naturally spawning parents, and a small fraction of strays from the Snake and Columbia River hatchery programs.
Two MaSAs exist in the Middle Fork John Day River population, including Middle Fork John Day and Long Creek, and no MiSAs.
The population exhibits a summer life history strategy and is part of the John Day River MPG.
It is considered an Intermediate population with a mean minimum abundance threshold of 1,000 spawners.
Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)
Abundance: Minimum abundance threshold of 1,000 spawners.
Productivity: Minimum productivity level of 1.35 recruits per spawner at the threshold abundance.
Viability Assessment Results
Abundance/Productivity: The population is at moderate risk based on current abundance and productivity. The point estimate is between 5% and 25% risk curves.
Spatial Structure/Diversity: The integrated SS/D rating is low risk for the population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was between very low and low risk. Current spawner distribution mimics the intrinsic distribution. The population is distributed broadly across the landscape, in multiple MaSAs with adequate gaps and good continuity between spawning areas. The rating for Goal B "maintaining natural levels of variation" was low risk; however, additional genetics analyses are needed to better assess genetic variation and hatchery introgression. The population rated high risk for proportion of out-of-DPS hatchery strays based on a limited time series of composite John Day population data. Better population specific spawner composition data are needed to better understand the out-of-DPS hatchery stray influence. If significant hatchery introgression affects genetic variation through time, then the risk rating will increase, thus raising the overall risk rating for Goal B and the overall SS/D rating.
Overall Viability Rating: The population *does not currently meet the recommended viability criteria*, although it does meet criteria for a "maintained" population. Increased annual abundance would allow this population to achieve a risk rating of low for A/P and raise the overall viability rating to viable.
Viability Gap
Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 756 is 75.6% of the threshold abundance of 1,000. The current productivity of 2.45 recruits per spawner is above the minimum needed at threshold abundance. The lower end of the 90% CI is well above the 25% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.08. This gap is a result of the difference in equilibrium abundance (928) and the threshold abundance.
Spatial Structure/Diversity: All metrics rated very low or low risk except for the following: *Spawner composition:* Out-of-DPS spawners rated high risk due to the high estimated proportion of out-of-DPS strays within this population.
Limiting Factors and Threats
Primary Limiting Factors: Tributary Habitat: degraded channel structure and complexity (habitat quantity and diversity), degraded floodplain function and connectivity, altered sediment routing, altered hydrology, and water temperature; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.
Primary Threats: Hatchery management that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, passage barriers, irrigation withdrawals, mining and dredging); the Columbia River mainstem hydro system.
Primary Life Stages Affected: fry-to-smolt, egg incubation; egg-to-parr, smolts, adult spawning.
VSP Characteristics Impacted: Abundance, productivity, diversity.
Tributary Management Strategies and Actions (Highest Priority)
Habitat Strategies
Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs.

Priority areas: Upper reaches of Big, Big Boulder, and Granite Boulder creeks that originate in the Vinegar Hill-Indian Rock Scenic Area.

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Mainstem Middle Fork John Day (Crawford to Bridge Cr, Horse to Camp Cr, Long Cr, Camp Cr).

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, stabilize streambanks. *Priority areas*: Middle Fork from mouth of Granite Boulder Cr to Ragged Cr, between Big Boulder Cr and Camp Cr, and near the mouth of Mosquito Cr

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures; improve irrigation conveyance and efficiency. *Priority areas:* Long Cr and tributaries

Harvest Strategies

Strategy: Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries.

Strategy: Reduce catch and release mortality on natural steelhead spawner. *Key actions*: voluntary curtailment of fishing at higher water temperatures.

Strategy: Improve quality of harvest. *Key actions*: expand creel surveys.

Hatchery Strategies

Strategy: Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* coded-wire-tagging program, development of alternative broodstocks.

Strategy: Reduce uncertainty in abundance and proportion of stray hatchery fish spawning naturally. *Key actions:* increased monitoring on spawning grounds and possibly trapping.

Table 1-13. Summary of Recovery Information for South Fork John Day River Population.

Key Population Attributes

The population occupies the South Fork drainage in the John Day River Basin. Steelhead spawn and rear through the lower South Fork John Day up to Izee Falls at RM 28.5 and in Murderers Creek and other South Fork tributaries.

Recent year natural spawners include returns originating from naturally spawning parents, and a small fraction of strays from the Snake River and Columbia River hatchery programs.

The population includes three MaSAs: Upper South Fork, Lower South Fork and Murderers Creek.

It exhibits a summer life history strategy and is part of the John Day River MPG.

The population is considered a Basic population with a mean minimum abundance threshold of 500 spawners.

Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)

Abundance: Minimum abundance threshold of 500 spawners.

Productivity: Minimum productivity level of 1.56 recruits per spawner at the threshold abundance.

Viability Assessment Results

Abundance/Productivity: The population is at moderate risk based on current abundance and productivity. The point estimate resides between the 25% and 5% viability curves. The lower bound of the adjusted standard error for both the productivity and abundance extend below the 25% risk level.

Spatial Structure/Diversity: The integrated SS/D rating is low risk for the population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" rated midway between very low and low risk. Although the current spawner distribution mimics the intrinsic distribution, only three MaSAs exist within the population. Good continuity exists between spawning areas and gaps between areas have remained relatively unchanged. The rating for Goal B "maintaining natural levels of variation" is low risk. As is the case for all John Day steelhead populations, there is uncertainty in ratings of metrics "genetic variation" and "proportion of spawners that are out-of-DPS strays." Limited genetics data for South Fork steelhead restrict efforts to determine if the current population variation is similar to historical conditions and to examine the degree of hatchery fish introgression. The metric for proportion of out-of-DPS strays rated as high risk. However, the analyses relied on composite data from four John Day populations. Additional population specific spawner composition data are needed to better inform the risk rating and to reduce the associated uncertainty.

Overall Viability Rating: The population *does not currently meet the recommended viability criteria*, although it does meet

criteria for a "maintained" population. Improvement in abundance will allow this population to achieve viable status. However, while the population received a SS/D rating of low risk, there is considerable uncertainty surrounding the spawner composition data. Enhanced monitoring of the hatchery-wild ratios on the South Fork spawning grounds should be conducted to improve the hatchery fraction estimate and reduce the degree of uncertainty.

Viability Gap

Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 259 is 51.8% of the threshold abundance of 500. The current productivity of 2.00 recruits per spawner is greater than the minimum required at the abundance threshold. The lower end of the 90% CI extends well below the 25% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.22. The uncertainty gap for the 1% risk level is 0.23. The gaps are primarily a result of the difference between the equilibrium abundance (409) and the threshold abundance.

Spatial Structure/Diversity: All metrics rated very low or low risk except the following: *Spawner composition*: Out-of-DPS spawners rated high risk due to the high estimated proportion of out-of-DPS strays within this population.

Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: altered sediment routing, degraded channel structure and complexity (habitat quantity and diversity), altered hydrology and low flow, water temperature, and impaired fish passage; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.

Primary Threats: Hatchery management that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, fish passage barriers (culverts, and other seasonal barriers), and irrigation withdrawals); the Columbia River mainstem hydro system.

Primary Life Stages Affected: Juvenile rearing, adult spawning, egg incubation, egg-to-parr survival, smolts.

VSP Characteristics Impacted: Abundance, productivity, diversity.

Tributary Management Strategies and Actions (Highest Priority)

Habitat Strategies

Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: Lower Murderers Cr tributaries draining the south side of Aldrich Mountain.

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Upper South Fork River above Izee Falls, SF Murderers Cr, Deer Cr

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, stabilize streambanks. *Priority areas*: same as for riparian strategy.

Strategy: Restore degraded floodplain connectivity and function. *Key actions*: Reconnect floodplain to channel, reconnect side channels and off-channel habitats, restore wet meadows. *Priority areas:* SF Murderers Cr, Deer Cr, Upper South Fork River above Izee Falls.

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures; improve irrigation conveyance/efficiency. *Priority areas:* SF Murderers Cr, Deer Cr, Upper South Fork River above Izee Falls.

Harvest Strategies

Strategy: Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries.

Strategy: Reduce catch and release mortality on natural steelhead spawner. *Key actions*: voluntary curtailment of fishing at higher water temperatures.

Strategy: Improve quality of harvest information. *Key actions*: expand creel surveys.

Hatchery Strategies

Strategy: Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* enhance coded-wire-tagging program, development of alternative broodstock.

Strategy: Reduce uncertainty in abundance and proportion of stray hatchery fish spawning naturally. *Key actions:* increased monitoring on spawning grounds and trapping.

Table 1-14. Summary of Recovery Information for Upper Mainstem John Day River Population.

Key Population Attributes
The population occupies the John Day River drainage above the town of Dayville and the mouth of the South Fork John Day River.
Recent year natural spawners include returns originating from naturally spawning parents and a small fraction of strays from the Snake River and Columbia River hatchery programs.
The population includes five MaSAs, Upper John Day, Upper Middle Mainstem John Day, Laycock, Beech and Canyon, and no MiSAs. The MaSAs are located primarily in the upper portions of the population boundaries.
The population exhibits a summer life history strategy and is part of the John Day River MPG.
It is considered an Intermediate population with a mean minimum abundance threshold of 1,000 spawners.
Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)
Abundance: Minimum abundance threshold of 1,000 spawners.
Productivity: Minimum productivity level of 1.35 recruits per spawner at the threshold abundance.
Viability Assessment Results
Abundance/Productivity: The population is at moderate risk based on current abundance and productivity. The point estimate for abundance and productivity resides between the 5% and 25% risk curves.
Spatial Structure/Diversity: The integrated SS/D rating is moderate risk for the Upper Mainstem John Day River population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was very low because the current distribution is nearly identical to the historical distribution. The rating for Goal B "maintaining natural levels of variation" was moderate risk. This risk rating was a result of a moderate rating for changes in major life history strategies. Additional genetics information needs to be assessed to determine current genetic variation and to examine for the degree of introgression of hatchery fish. The population was rated as high risk for out-of-DPS hatchery strays based on a limited time series of composite John Day population hatchery fish observation data. Better population specific spawner composition data are needed to better determine the out-of-DPS hatchery fraction. If there is significant hatchery introgression that affects the genetic variation of this population through time, then the risk rating for Goal B will increase, and the overall risk rating for SS/D will increase.
Overall Viability Rating: The population *does not currently meet the recommended viability criteria*, although it does meet criteria for a "maintained" population. An increase in abundance is needed for this population to achieve viable A/P criteria. In addition, the SS/D rating was moderate due to loss in life history diversity and high risk for spawner composition.
Viability Gap
Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 524 is only 52.4% of the threshold abundance of 1,000. The current productivity of 2.14 recruits per spawner is well above the minimum required at the threshold abundance. The lower end of the 90% CI resides above the 25% risk level. The observed A/P gap to reach the 5% and 1% risk levels is 0.37. The uncertainty gaps are less than the observed gaps. The gap is primarily a result of the difference in the equilibrium abundance (730) and the threshold abundance.
Spatial Structure/Diversity: Gaps were identified for the following SS/D metrics: *Major life history strategies:* moderate risk due to reduced opportunities for juvenile movement patterns and reduced summer rearing distribution that has resulted from altered mainstem and tributary habitats. *Spawner composition:* Out-of-DPS spawners rated high risk due to the high proportion of out-of-DPS strays and uncertainty in the estimates of hatchery fraction.
Limiting Factors and Threats
Primary Limiting Factors: Tributary Habitat: degraded channel structure and complexity (habitat quantity and diversity), degraded riparian areas and LWD recruitment, altered sediment routing, water temperatures, altered hydrology and degraded floodplain function and connectivity. Impaired fish passage is also a priority limiting factor in Beech and Laycock creeks. *Hatchery:* effects of naturally spawning stray hatchery fish on viability. *Hydro:* mainstem passage.
Primary Threats: Hatchery production that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (agricultural practices, livestock overgrazing, removal of large trees from the riparian corridor, wetland draining/conversion, stream channelization/diking); the Columbia River mainstem hydro system.
Primary Life Stages Affected: Juvenile rearing, egg incubation, egg-to-parr survival, smolts, adult spawning.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.
Tributary Management Strategies and Actions (Highest Priority) *Habitat Strategies* *Strategy*: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: EF and Middle Fork of Canyon Cr, John Day River above Blue Mt. Hot Springs. *Strategy*: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Upper mainstem John Day River, Beech Cr, Bear Cr, lower reaches of Fields Cr, Belshaw Cr and Riley Cr. *Strategy:* Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, stabilize streambanks. *Priority areas*: Mainstem John Day River (Dayville to Blue Mt. Hot Springs), Indian Cr, Pine Cr, lower Beech Cr, middle Canyon Cr, lower Strawberry Cr *Strategy*: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement water conservation measures; improve irrigation conveyance/efficiency. *Priority areas:* Fields, Indian, Pine, Beech, Strawberry and Laycock creeks, John Day River (Dayville to Mt. Vernon). *Strategy*: Restore passage and connectivity. *Key actions*: Remove or minimize use of push up dams, remove or replace culverts and/or other passage barriers. *Priority areas*: Beech, Canyon, Strawberry, Dixie, and Reynolds creeks. *Harvest Strategies* *Strategy:* Use harvest to reduce stray hatchery spawners. *Key actions*: selective fisheries. *Strategy:* Reduce catch and release mortality on natural steelhead spawner. *Key actions*: voluntary curtailment of fishing at higher water temperatures. *Strategy:* Improve quality of harvest information. *Key actions*: expand creel surveys. *Hatchery Strategies* *Strategy:* Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* enhance coded-wire-tagging program, development of alternative broodstocks. *Strategy:* Reduce uncertainty in abundance and proportion of stray hatchery fish spawning naturally. *Key actions:* increased monitoring on spawning grounds and trapping.

Table 1-15. Summary of Recovery Information for Umatilla River Population.

Key Population Attributes The Umatilla River steelhead population occupies the Umatilla watershed and a few smaller streams in Washington State that flow directly into the Columbia River. Recent year natural spawners include returns originating from naturally spawning parents, Umatilla River hatchery-origin fish and out-of-DPS strays, primarily from the Snake River Basin. The ICTRT has identified 13 MaSAs for this steelhead population. Eleven of the MaSAs are within the Umatilla drainage in Oregon: Butter, East Birch, McKay, Meacham, Middle Umatilla, Upper Umatilla, Lower Middle Umatilla, Lower Birch, Lower Umatilla, Wildhorse and West Birch. The population also has three MiSAs: Alkali, Fourmile Canyon, and Cottonwood. Two of the MaSAs, Alder Creek and Glade Creek, are included in the Umatilla population, but are direct tributaries to the Columbia River on the Washington side. Currently only eight of the 13 MaSAs are occupied. The population exhibits a summer life history strategy and is part of the Umatilla/Walla Walla Rivers MPG. It is considered a Large population with a mean minimum abundance threshold of 1,500 spawners.
Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk) *Abundance:* Minimum abundance threshold of 1,500 spawners. *Productivity:* Minimum productivity level of 1.26 recruits per spawner at the threshold abundance.
Viability Assessment Results *Abundance/Productivity*: The population is at moderate risk. The productivity is at low risk because the point estimate is above 5% risk level and the adjusted standard error is above the 25% risk level. Abundance is moderate because the point estimate is slightly below the 5% risk level.

Spatial Structure/Diversity: The integrated SS/D rating is moderate risk for the population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was moderate risk. There has been significant reduction in spawner distribution relative to intrinsic potential distribution. This reduction has caused significant increases in gaps between spawning areas as well as disrupted continuity. The rating for Goal B "maintaining natural levels of variation" was moderate risk. Habitat changes have been significant in the Umatilla Basin resulting in changes to flow profiles and elevated temperatures. These changes have resulted in impacts to life history diversity and phenotypic trait variation. The out-of-DPS strays in combination with local origin hatchery fish spawning naturally put the population at high risk for spawner composition. Within basin habitat changes have likely resulted in selective mortality of specific components of juvenile and adult life stages resulting in a moderate risk rating.

Overall Viability Rating: The population *does not currently meet the recommended viability criteria* because A/P and SS/D risks ratings are both moderate. It does meet criteria for a "maintained" population. Improvement in many of the SS/D metrics and a small increase in the average abundance will raise the population to viable status.

Viability Gap

Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 1,472 is 98.1% of the threshold abundance of 1,500. The current productivity of 1.50 recruits per spawner is above the minimum of 1.26 required at the threshold abundance. The lower end of the 90% CI resides slightly above the 25% risk level. The observed A/P gap for the 5% and 1% risk levels is 0.09. The uncertainty gap for the 1% risk level is less than the observed gap.

Spatial Structure/Diversity: Gaps were identified for the following SS/D metrics: *Spatial Extent or Range of Population*: moderate risk because the current spawner distribution is substantially reduced from the historical distribution. Loss of spawning in the Butter and McKay watersheds has resulted in the reduced distribution. *Increase or decrease in gaps and continuities*: moderate risk because of the increased gaps and changed continuity resulting from losses of occupancy in the Butter and McKay watersheds. *Major life history strategies:* moderate risk as a result of reduced opportunity for life history expression for juvenile and adult life stages. This reduced opportunity has resulted from significant habitat changes in the Umatilla Basin. *Phenotypic variation:* moderate risk due to effects of flow and temperature on adult and juvenile migration characteristics. *Spawner composition*: Overall rating is high risk due to two moderate ratings for the component metrics. Out-of-DPS spawners rated as moderate risk due to the estimated level of strays observed at Three-mile Falls Dam over the last three generations. Within-population spawners rated moderate risk due to the proportion and duration of Umatilla Hatchery fish spawning in the basin. *Selective change in Natural Processes-Habitat:* moderate risk due to the selective effects of temperature and flow changes on juvenile and adult characteristics.

Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: high water temperature, sediment routing, impaired fish passage, degraded channel structure and complexity and low flows; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.

Primary Threats: Hatchery production that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices that reduce habitat quality, quantity and disrupt ecosystem functions; the Columbia River mainstem hydrosystem.

Primary Life Stages Affected: fry, summer parr, winter parr, smolts.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

Tributary Management Strategies and Actions (Highest Priority)

Habitat Strategies

Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas:* North Fork Umatilla R, Umatilla R (Meacham Cr. to forks), Buck Cr, NF Meacham Cr, E. Meacham Cr, Thomas Cr, W. Birch Cr (Bear Cr to headwaters), E. Birch Cr (California Gulch to headwaters), SF Umatilla R (mouth to Thomas Cr).

Strategy: Restore passage and connectivity. *Key actions*: Remove or replace culverts and/or other passage barriers, construct ladders over existing dams, provide adequate screening at all irrigation diversions. *Priority areas*: Birch Cr, W. Birch Cr, Bridge Cr, and diversions within current steelhead distribution.

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Umatilla R (Mission Br to forks), Meacham Cr (mouth to headwaters), Birch Cr, West Birch Cr (mouth to Gorge), East Birch Cr,

Bear Cr, Iskuulpa Cr.

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, stabilize streambanks. *Priority areas*: Umatilla R (Mission Br. to forks), Meacham Cr, NF Meacham Cr, Birch Cr, West Birch Cr (mouth to Gorge), East Birch Cr, Bear Cr.

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Implement Umatilla Basin Project Phases I-IIII, implement water conservation measures, improve irrigation conveyance/efficiency. *Priority areas:* Umatilla R (mouth to Thornhollow), Birch C, West Birch Cr (mouth to Gorge), East Birch Cr, Bear Cr.

Hydrosystem Strategies

Strategy: Improve hydrosystem operations and facilities at Boyd Project to enhance steelhead survival and viability. *Key actions:* Modify bypass flows at Project if possible to mimic instream water right, modify fish passage facilities to meet current standards, remove weir panels from diversion dam during non-operation, maintain trash racks. *Priority areas:* At and below Boyd Project.

Harvest Strategies

Strategy: Manage harvest to maintain current low impact fisheries. *Key actions:* Maintain current low impact fisheries.

Hatchery Strategies

Strategy: Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* coded-wire-tagging program, development of alternative broodstocks for the hatchery programs that produce the strays.

Strategy: Reduce abundance and proportion of out-of-basin stray hatchery fish spawning naturally. *Key actions:* no consensus actions.

Strategy: Re-establish natural production in historically utilized areas. *Key actions*: re-establish natural production in Little Butter and Butter creeks and some MiSAs through adult outplanting and juvenile releases.

Strategy: Reduce genetic influence of hatchery fish in broodstock. *Key actions*: Eliminate use of hatchery produced adults in broodstock.

Strategy: Reduce interactions between residual hatchery steelhead and natural steelhead. *Key actions*: no consensus actions.

Strategy: Reduce potential ecological interactions between coho and natural steelhead. *Key actions*: reduce number of hatchery coho released in Umatilla R. and relocate releases downstream of areas important to steelhead production.

Table 1-16. Summary of Recovery Information for Walla Walla River Population.

Key Population Attributes

The Walla Walla River steelhead population occupies the Walla Walla watershed, with the exception of the Touchet River drainage, which is considered a separate independent steelhead population. The main tributaries of the Walla Walla River are the North and South forks and Couse, Pine, Birch, Cottonwood and Mill creeks. The North and South forks and Couse Creek are entirely within Oregon, but the remaining tributaries span the state line. Two small watersheds that empty directly into the Columbia River below the Walla Walla River confluence are included in the Walla Walla population boundaries.

Recent years natural spawners include returns originating from naturally spawning adults and from outside-DPS strays that originate from Lyons Ferry Hatchery releases in the lower Walla Walla River.

The population is comprised of three MaSAs (Mill, Pine, and Walla Walla) and two MiSAs (Dry and Switzler). Currently two of three MaSAs are occupied, including Walla Walla and Mill. Spawning and rearing occur in the lower reaches of the Pine Creek MaSA.

The population exhibits a summer life history strategy and is part of the Umatilla/Walla Walla Rivers MPG.

It is considered an Intermediate size population with a mean minimum abundance threshold of 1,000 spawners.

Minimum Viability Levels For Low Risk Recovery Scenario (5% extinction risk)

Abundance: Minimum abundance threshold of 1,000 spawners.

Productivity: Minimum productivity level of 1.35 recruits per spawner at the threshold abundance.

Viability Assessment Results

Abundance/Productivity: The population is at moderate risk based on current abundance and productivity. The point estimate falls between the 5% and 25% risk curves. The risk rating should be viewed with caution given two considerations. First, the time series is short, with only eight complete brood years. Second, there is considerable uncertainty associated with the amount of spawning and production that occurs within the population outside of the area above Nursery Bridge Dam, particularly in Mill Creek. Better information relating abundance above Nursery Bridge Dam to the remaining area in the population is needed to reduce these data uncertainties.

Spatial Structure/Diversity: The integrated SS/D rating for the population is moderate risk. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was moderate risk. There has been significant reduction in spawner distribution which has resulted in increased gaps and loss of continuity within the population, as well as between the Walla Walla population and other Mid-Columbia steelhead populations. The rating for Goal B "maintaining natural levels of variation" was moderate risk. Water temperature and hydrograph changes, as well as barriers have likely influenced life history diversity and phenotypic expression. Out-of-DPS strays have put the population in the moderate risk category for the spawner composition metric. Within basin habitat changes have likely resulted in selective mortality at multiple life stages resulting in a moderate risk rating.

Overall Viability Rating: The population *does not currently meet the recommended viability criteria*, although it does meet criteria for a "maintained" population. The A/P values are at moderate risk and the time series is short resulting in considerable uncertainty. Additional brood years are needed to demonstrate sustained recruits per spawner and abundance values above the low risk criteria level. Significant improvements to spatial structure and diversity are needed to improve the risk level.

Viability Gap

Abundance/Productivity: The recent 10-year geomean natural-origin abundance of 650 is well below the threshold abundance of 1,000. The current productivity of 1.34 recruits per spawner is slightly less than the minimum of 1.35 required at the threshold abundance. The lower end of the 95% CI extends well below the 25% risk level. The observed gaps for A/P at the 5% and 1% risk levels were 0.34 and 0.45 respectively. The uncertainty gaps at the 5% and 1% risk levels were less than the observed gaps. These gaps should be viewed cautiously because there is only a short data series available to estimate productivity.

Spatial Structure/Diversity: Gaps were identified for the following SS/D metrics: *Major life history strategies:* moderate risk due to changes in juvenile and adult movement patterns as well as reduced juvenile rearing distribution relative to historical opportunities. The reduced life history strategies have resulted from significant flow and temperature changes within the basin. *Phenotypic variation:* moderate risk due to the effect of flow and temperature changes on phenotypic variation. Adult and juvenile migration patterns have been significantly altered due to these habitat changes. *Spawner composition:* Out-of-DPS spawners rated moderate risk due to the proportion and duration of out-of-DPS spawners in the population. *Selective change in Natural Processes-Habitat:* moderate risk due primarily flow and temperature effects on migration, movement and rearing patterns.

Limiting Factors and Threats

Primary Limiting Factors: Tributary Habitat: high water temperature, sediment routing, impaired fish passage, degraded channel structure and complexity, degraded floodplain connectivity and function, and low flow; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.

Primary Threats: Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices that reduce habitat quality, quantity and disrupt ecosystem functions; the Columbia River mainstem hydrosystem.

Primary Life Stages Affected: fry, summer parr, winter parr, smolts.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

Tributary Management Strategies and Actions (Highest Priority)

Habitat Strategies

Strategy: Protect and conserve natural ecological processes. *Key actions*: Protect highest quality habitats; apply BMPs. *Priority areas*: SF Walla Walla (Elbow to headwaters), SF Walla Walla Tribs, NF Walla Walla (Little Meadows to headwaters).

Strategy: Restore passage and connectivity. *Key actions*: Remove or replace culverts and/or other passage barriers, construct ladders over existing dams, provide adequate screening at all irrigation diversions. *Priority areas*: Mill Cr., Birch Cr, Couse Cr, and unscreened irrigation diversions within current steelhead distribution.

Strategy: Restore riparian condition and LWD recruitment. *Key actions*: restore natural plant communities, maintain fencing, adjust grazing strategies (new fencing may be part of an adjusted strategy). *Priority areas*: Walla Walla R (Mill Cr. to forks), SF Walla Walla (mouth to Elbow Cr), NF Walla Walla R (mouth to Little Meadows Cyn).

Strategy: Restore degraded and maintain properly functioning channel structure and complexity. *Key actions*: restore natural channel form, increase LWD, and stabilize streambanks. *Priority Areas*: Walla Walla R (Mill Cr. to forks), SF Walla Walla (mouth to Elbow Cr), NF Walla Walla R (mouth to Little Meadows Cyn).

Strategy: Restore natural hydrograph to provide sufficient flow during critical periods. *Key actions*: Investigate feasibility of water storage or exchange, implement water conservation measures, and improve irrigation conveyance/efficiency. *Priority Areas:* Walla Walla R (mouth to Little Walla Walla diversion), Walla Walla R. (Mill Cr to forks), NF Walla Walla R (mouth to Little Meadows Cyn).

Hydrosystem Strategies

Strategy: Improve hydro operations and facilities at Twin Reservoirs Project. *Key actions:* Conduct assessment of fishway and modify to meet juvenile fish passage standards.

Harvest Strategies

Strategy: Manage harvest to maintain current low impact fisheries. *Key actions:* Maintain current low impact fisheries.

Hatchery Strategies

Strategy: Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery fish. *Key actions:* enhance coded-wire-tagging program, development of alternative broodstocks for the hatchery programs producing strays.

Strategy: Reduce abundance and proportion of hatchery strays spawning naturally. *Key actions:* no consensus actions.

Section 2 Introduction

This plan provides a framework and roadmap for the conservation and recovery of Middle Columbia River (Mid-C) steelhead (*Oncorhynchus mykiss)* in the State of Oregon. Mid-C steelhead currently occupy habitat in five major Oregon subbasins: Fifteenmile Creek and the Deschutes, John Day, Umatilla and Walla Walla rivers, as well as a number of small tributaries that flow directly into the Columbia River. The plan focuses on the recovery of Mid-C steelhead populations in these subbasins.

Oregon Mid-C steelhead were originally listed as threatened under the Endangered Species Act (ESA) as part of the Middle Columbia River steelhead Evolutionarily Significant Unit (ESU) on March 25, 1999 (69 FR 33101). After NOAA Fisheries' National Marine Fisheries Service (NMFS) revised its species determinations for West Coast steelhead, Mid-C steelhead populations were listed as threatened on January 5, 2006 (71 FR 834) as the Middle Columbia River steelhead Distinct Population Segment (DPS). The DPS includes all steelhead populations in Oregon and Washington tributaries of the Columbia River upstream of the Hood and Wind River systems, up to and including the Yakima River. The Snake River is not part of the DPS.

The draft recovery plan describes a process to remove or minimize the threats to the long-term survival and recovery of Mid-C steelhead and improve the viability to the level that protection under the ESA is not required.

The document describes:

- The institutional framework and rationale for recovery plans
- How NOAA's National Marine Fisheries Service expects to use the plan
- The regional domains of the Columbia Basin within which the recovery plans are written
- The relation of this plan to other planning processes and other ESA mandates
- Desired status--delisting (viability) criteria and broad sense recovery goals
- The current status of listed Mid-C steelhead
- Gaps between current status and viable status
- Limiting factors and threats
- Recovery strategies, management strategies and actions
- Management action effectiveness
- Cost analysis
- Research, monitoring and evaluation
- A framework for implementation and adaptive management

2.1 Species Recovery under ESA

Section 4(f) of the ESA requires NMFS to develop and implement recovery plans for species listed as endangered or threatened under the Act. These plans must, at a minimum, contain (1) a description of site-specific management actions necessary to achieve the plan's goal for the conservation and survival of the species; (2) objective, measurable criteria that, when met, would result in a determination that the species be removed from the list; and, (3) estimates of the time

required and cost to carry out the measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal. Recovery plans are guidance and not regulatory documents, thus no agency or entity is required by the ESA to implement the recovery strategies or actions in the plans unless otherwise legally mandated (NMFS 2006a). Although not regulatory, the authors of the ESA clearly saw recovery plans as a central guiding vehicle for the recovery of listed species.

NMFS is the agency responsible for recovery planning for salmon and steelhead, and also for decisions to list and delist marine species as endangered or threatened. Nevertheless, NMFS recognizes that local support of recovery plans is essential to their successful implementation. It is committed to involving local citizens and groups — those whose activities directly affect the listed species, and whose activities are most affected by recovery requirements — in development of the plans. The State of Oregon has taken the lead, in collaboration with NMFS and many other agencies, in developing the recovery plan for Oregon Mid-C steelhead. This plan fulfills the initial ESA recovery planning requirements for Mid-C steelhead, and represents the participation and leadership of tribal and non-tribal citizen groups.

As a template for listed species recovery, a recovery plan describes a process to remove the threats to long-term survival and persistence by reversing the decline of a listed species and its habitat so that they initially become viable and eventually achieve their historical role in the natural-cultural system of the Columbia Basin. A recovery plan provides the necessary information that Federal agencies (NMFS and the U.S. Fish and Wildlife Service (USFWS)) have determined will lead to recovery of listed species and their associated habitats. The plan describes the current species status, the 'gap' that needs addressing to reach recovery, as well as ongoing or proposed actions designed to aid in the recovery of the species. The plan also provides estimated timeframe and costs for the overall effort. The final recovery plan will be considered a "living document." As new information becomes available, such as the outcome of the Federal Columbia River Power System Biological Opinion process, better understanding of climate change, or as monitoring and adaptive management reveal the need for change, revised and additional actions will be added to the plan.

Once a species is deemed recovered, and therefore removed from a 'listed status,' section 4(g) of the ESA requires the monitoring of the species for a period of not less than five years to ensure that it retains its recovered status and does not decline to such a state that requires the need to again list it as either a threatened or endangered species under the ESA.

2.2 State of Oregon Recovery Planning

The State of Oregon considers this plan its conservation plan for the Oregon portion of the Middle Columbia River steelhead DPS. The plan supports the State of Oregon's Plan for Salmon and Watersheds (Oregon Plan) and meets the requirements of Oregon's Native Fish Conservation Policy (NFCP) (OAR 635-007-0502 to 0509). The Oregon Plan is a comprehensive partnership between government, communities, private landowners, industry and citizens funded by the Oregon Legislature. The Oregon Plan mission is:

> *To restore the watersheds of Oregon and to recover the fish and wildlife populations of those watersheds to productive and sustainable levels in a manner that provides substantial environmental, cultural and economic benefits.*

The Native Fish Conservation Policy, adopted in 2002 by the Oregon Fish and Wildlife Commission, provides refined policy to support implementation of the Oregon Plan. The NFCP is Oregon's policy for managing native fish and determining restoration priorities that improve the effectiveness of conservation efforts under the Oregon Plan. The NFCP focuses on the conservation of naturally produced fish because they are the basis for Federal ESA listings and are the foundation for productive fisheries programs.

The NFCP uses conservation plans as a means to identify and implement strategies and actions to restore and maintain native fish in Oregon. The conservation plans describe commitments by the State of Oregon that will conserve the sustainability of ESUs/DPSs and restore biological attributes necessary to achieve desired status goals that will provide significant ecological, economic and cultural benefits for all Oregonians. The plans are developed through a sequential process, nearly identical to the one used for this recovery planning effort:

1. Determine the management unit, ESU or DPS
2. Determine its current status
3. Define a desired status (viability and broad sense goals)
4. Determine any gap between the two and the factors causing the gap (limiting factors)
5. Identify strategies and actions that address the limiting factors
6. Monitor and evaluate the ESU (or DPS) status and actions implemented and use adaptive management to make adjustments.

Status assessments conducted under the NFCP resemble assessments for ESA recovery in that they focus on groups of populations from a common geographic area with similar genetic and life history traits called Species Management Units (SMUs). Oregon, however, believes there are ecological and adaptive differences between summer and winter forms of steelhead and separates them into different SMUs. Populations delineated within Oregon's Mid-C summer steelhead SMU are similar to those defined for the Cascade Eastern Slope Tributaries MPG, except that the Deschutes Eastside and Westside populations are combined into a single population and the Fifteenmile Creek winter steelhead population is included in the Lower Columbia winter steelhead SMU. Oregon currently considers both SMUs as "At Risk" (ODFW 2005d). We chose to use the ICTRT population delineations because they were developed based on more recent information. We do not believe that the delisting criteria or management actions would differ if the Oregon NFCP populations or SMU boundaries were used because of the close similarity to the ICTRT boundaries.

As a conservation plan under the NFCP, this plan for Oregon Mid-C steelhead populations goes beyond achieving ESA recovery requirements. Its desired status includes achievement of 'broad sense goals', including meeting social and cultural benefits. This approach to species recovery includes development of goals for harvestable population levels viewed essential by all the parties involved. Although somewhat broader than the definition of recovery provided by the

ESA, these broad sense recovery goals incorporate many of the traditional uses as well as rural and Native American values deemed important in Oregon and throughout the Pacific Northwest.

Consistent with the Oregon Plan and NFCP — as well as the ESA — this plan provides structure and guidance to efforts to protect and restore Oregon Mid-Columbia steelhead and their habitats, while providing flexibility for actions to be determined by appropriate parties. It is designed to support and build on the existing conservation network across Oregon's portion of the DPS. This partnership of regulatory and non-regulatory entities, private landowners, and others represents an effective means for achieving viability targets and broader recovery goals.

This Recovery Plan was developed to parallel and build from the Oregon Conservation Strategy. The Oregon Conservation Strategy (Conservation Strategy) was developed by ODFW in response to a national effort guided by the U.S. Congress and the U.S. Fish and Wildlife Service to encourage states to develop comprehensive wildlife conservation plans. The Oregon Fish and Wildlife Commission approved the Conservation Strategy in August 2005 and the strategy was approved by the USFWS in March 2006. The Conservation Strategy provides a long-term, big picture "blueprint" for conserving Oregon's natural resources. The strategy is designed to maintain and improve environmental health for today and future generations. The principle goal is to "maintain healthy fish and wildlife populations by maintaining and restoring functioning habitats, prevent declines of at-risk species, and reverse declines in these resources where possible." Like the Recovery Plan, the Conservation Strategy is not a regulatory document and relies on voluntary conservation actions. Mid-Columbia River steelhead are identified as a "Strategy Species" that are distributed throughout three ecoregions specified as critical for achieving the goals of the Conservation Strategy. The Conservation Strategy identifies six key issues for which specific goals and actions are presented. All of the actions identified within this Recovery Plan align with the key issues and goals identified in the Conservation Strategy. The limiting factors and management actions described in this Recovery Plan are more spatially and temporally explicit than the actions in the Conservation Strategy. In addition, this plan addresses a wider array of issues such as hydrosystem, harvest, hatcheries and predation.

2.3 Tribal Treaty/Trust Obligations

Northwest Indian tribes have legally enforceable treaty rights reserving to them a share of the salmon harvest, and they are "co-managers" with state and federal agencies in regulating salmon harvest. These rights and expectations may not necessarily be fully met by achieving the basic purposes of the ESA and delisting of the species, although it will lead to major improvements in the current situation.

Historically, Mid-C steelhead were found throughout central Oregon and south-central Washington. Mid-C steelhead were important to Native Americans of the interior west, including the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Confederated Tribes of the Warm Springs Reservation. Native Americans throughout the Pacific Northwest maintain strong cultural values for steelhead and salmon species. These fish have long had important tribal subsistence, ceremonial and commercial value. Steelhead have also been, and continue to be, of importance to the recreational fishing industry of the region.

Several treaty tribes exist within the area considered the range of Mid-C steelhead; the Yakama, Umatilla, Walla Walla, and Warm Springs tribes. The Treaty of June 9, 1855 was between the United States and the Walla Walla, Cayuse, and Umatilla Tribes, now the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). In 1855 the Warm Springs and Wasco tribes signed with the United States in the Treaty with the Middle Oregon Tribes of Oregon. The Confederated Tribes of the Warm Springs (CTWSRO) consists of the Warm Springs, Wasco and Paiute tribes. The Confederated Tribes of the Yakama represent 14 bands and tribes that were a party of the 1855 Treaty with the Yakamas and United States.

Ensuring a sufficient abundance of salmon and steelhead to sustain harvest can be an important element in fulfilling treaty rights. NMFS is committed to meeting Federal treaty and trust obligations to the tribes. These obligations are described in a July 21, 1998 letter from Terry D. Garcia, Assistant Secretary for Oceans and Atmosphere, U.S. Dept of Commerce, to Mr. Ted Strong, Executive Director of the Columbia River Inter-Tribal Fish Commission. This letter states that recovery *"…must achieve two goals; 1) the recovery and delisting of salmonids listed under the provisions of the ESA; and 2) the restoration of salmonid populations over time, to a level to provide a sustainable harvest sufficient to allow for the meaningful exercise of tribal fishing rights."* Thus it is appropriate for recovery plans to take these conditions into account and plan for a recovery strategy that includes harvest.

The ESA and tribal trust responsibilities complement one another. Both depend on a steady upward trend toward ESA recovery and delisting in the near term, while making river, harvest, and land management improvements for the long term. Furthermore, ESA delisting cannot occur until both biological objectives and the listing factors are considered and NMFS determines, based on an evaluation of the listing factors, that the DPS is no longer likely to require the protection of the Act. Therefore, NMFS will make no delisting decision until it is clear that the threats to the DPS have been addressed and that the status and trends of both the fish and their habitats will be healthy and sustainable in the long term.

Section 3 Background and Regional Context

Section 3 describes the context of Oregon's recovery plan for Mid-C steelhead within the framework of NMFS's larger recovery planning efforts. It also describes the State of Oregon's process led by the Oregon Department of Fish and Wildlife to develop a scientifically sound, realistic road map for recovery through broad technical, stakeholder, and public involvement. In addition it identifies the recovery goals for the DPS, discusses the listing of Mid-C steelhead, and provides a short description of the population's life history characteristics and critical habitat.

3.1 Context of Plan Development

This recovery plan is one piece of a larger recovery planning effort for listed species across the Pacific Northwest, as well as in other parts of the Mid-C DPS. It is also part of a broader planning effort by the State of Oregon to conserve and rebuild Oregon's native salmon and steelhead runs. These overlapping processes are discussed in this section.

3.1.1 NMFS's Regional Process

Currently, 17 ESUs and DPSs of Pacific salmon and steelhead in the Pacific Northwest are listed under the ESA. NMFS has designated five geographically-based recovery domains for preparing recovery plans for the listed species. The Mid-C steelhead DPS falls within the Interior Columbia domain (which is divided into three sub-domains: the Snake River, Mid-Columbia, and Upper Columbia). The other domains are the Willamette-Lower Columbia; Puget Sound and Washington Coast; Oregon Coast; and the Southern Oregon/ Northern California Coast domains. Opportunities exist for technical and stakeholder involvement in each domain.

Technical Recovery Team
For each domain, NMFS appointed an independent Technical Recovery Team (TRT) that has geographic and species expertise for the domain and can provide a solid scientific foundation for recovery plans. The charge of each TRT is to define ESU/DPS structures, develop recommendations on biological viability criteria for ESUs/DPSs and populations, to provide scientific support to local and regional recovery planning efforts, and to provide scientific evaluations of recovery plans. The TRTs include biologists from NMFS, state, tribal, and local entities, agencies, academic institutions, and private consulting groups. All the TRTs operate from a common scientific foundation. Each TRT has used the same biological principles for developing its recommended ESU/DPS and population viability criteria — criteria that will be used, along with threats-based criteria, to determine whether a species has recovered sufficiently to be downlisted to threatened (if endangered) or delisted — although they have developed regionally specific approaches to these criteria. Each TRT's recommendations are assessed using the Viable Salmonid Population (VSP) framework, with viability criteria expressed in terms of abundance, productivity (population growth rate), spatial distribution, and diversity (McElhany et al. 2000).

Planning Forums

In each domain, NMFS has worked with state, tribal, local and other Federal stakeholders to develop planning forums appropriate to the domain, which builds to the extent possible on ongoing, locally led efforts. NMFS separated the Mid-Columbia River steelhead DPS into four management units (Figure 3-1) that reflect its diverse human and physical landscape: the Oregon Unit, Yakima Unit, Columbia Gorge Unit (Klickitat/White Salmon/Rock Creek), and Southeastern Washington Unit (Touchet and the Washington portion of the Walla Walla River).

Individual recovery plans developed by local forums for the four management units form the foundation of the DPS-level recovery plan. This recovery plan is for the Oregon management unit. The State of Washington took responsibility for recovery planning for the portion of the Mid-Columbia DPS within its borders. The State of Washington's Salmon Recovery Act established six regional boards that are comprised of government and tribal representatives, landowners, and private citizens. With substantial funding from Washington's Salmon Recovery Board and the Northwest Power and Conservation Council (NPCC), these groups produced the June 2005 Draft Snake River Salmon Recovery Plan for SE Washington, and the October 2005 Draft Yakima Subbasin Salmon Recovery Plan that address the drainages within the State of Washington regarding Mid-C steelhead. NMFS and representatives from the four management units worked together to develop DPS-level direction that identified the viability scenarios for Cascades Eastern Slope Tributaries and Umatilla/Walla Walla MPGs that overlap parts of Oregon and Washington states.

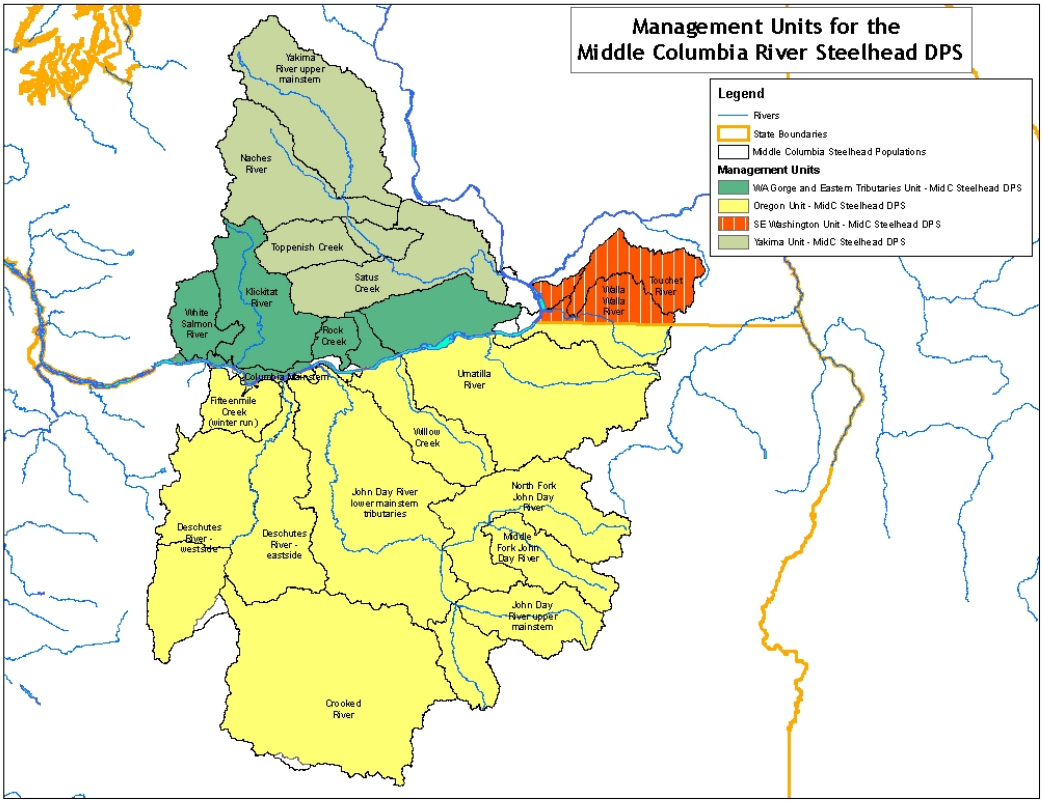


Figure 3-1. NMFS Management Units for the Middle Columbia River Steelhead DPS.

For more information about NMFS, the domains, and the TRTs, see the following Internet site: http://www.nwr.noaa.gov/Salmon-Recovery-Planning/index.cfm.

3.1.2 State of Oregon Recovery Planning Process

The State of Oregon developed this plan in partnership with other state and Federal natural resources agencies, the tribes, and local communities. The plan took shape through a collaborative process with broad technical, stakeholder and public involvement. The planning process drew on direction developed through related planning processes, included the NPCC subbasin plans, the Oregon Plan and Native Fish Conservation Policy planning. ODFW took the lead in drafting the Oregon Mid-C steelhead recovery plan with the assistance of a cadre of other entities. Members of ODFW, NMFS, Tribes, and many other contributors compiled the information for the Oregon portion of the Mid-Columbia River basin from multiple sources, including federal, state, tribal, private, and local watershed organizations that are involved in salmon recovery.

ODFW has involved critical players in the plan's development at each stage in the decision-making process. The plan reflects substantial the review, discussion, critique and recommendations of four primary forums: a State-level Expert Panel, a diverse public sounding board, a recovery planning team, and population-specific management action teams. Appendix A lists the members of each of these groups. The Interior Columbia TRT was also involved in the process. This involvement is vital to the plan's success and will help ensure that it is both scientifically and technically sound and supported by various stakeholders and private landowners.

- *Oregon Mid-Columbia Expert Panel*. The Expert Panel was created by the Oregon Department of Fish and Wildlife for purposes of recovery planning and consisted of biologists with significant knowledge of the limiting factors and threats influencing Oregon's listed salmon and steelhead populations. Panelists identified common key and secondary threat themes and limiting factors for the populations.

- *Mid-Columbia Sounding Board.* The Mid-Columbia Sounding Board (MCSB) consists of representatives of local communities, agricultural and timber interests, water users, land managers, governing bodies, tribes, and industry and environmental interests. The MCSB provides policy guidance in the development of all aspects of the plan and ensures locally appropriate and locally supported recovery actions needed to achieve species recovery goals. The MCSB was particularly instrumental in the development of broad sense recovery goals, recovery scenarios, recovery strategies, and strategic guidance for development and prioritization of management actions.

- *Mid-Columbia Recovery Planning Team.* The recovery planning team includes state, Federal, Tribal, and watershed council technical representatives across the DPS. The team provided technical guidance and assisted in writing different aspects of the plan.

- *Management Action Teams.* The three management action teams include local experts representing state and federal natural resource agencies, the tribes, watershed councils and Portland General Electric. The teams developed management actions for the ten steelhead populations.

Involvement by these different entities helps ensure that recovery goals and actions are consistent and compatible with the goals and direction adopted in related efforts. This integrated approach establishes partnerships that allow actions to be implemented effectively and efficiently.

Plan Review, Revision, Adoption and Implementation
Drafts of the Oregon Mid-C steelhead recovery plan were posted on the NMFS Web site to provide an opportunity for informal public response during the development phase. The initial 2005 draft was a framework and progress report intended to keep the interested reader abreast of the development of the draft plan. The 2007 draft was the first complete draft available for review.

This is the second complete draft of the recovery plan. It will be refined following extensive review, including a formal period of public comment through Federal and State processes, by public agencies, environmental organizations, landowners, interested public and other stakeholders. In spring 2009 the draft recovery plan will be revised and published in final form for public reference and use.

Once this recovery plan is approved, all federal and nonfederal funding entities should develop a coordinated, prioritized, and accountable funding strategy. To facilitate implementation, NMFS intends to provide streamlined regulatory assurances for actions that are undertaken to implement recovery. Adaptive management including a comprehensive monitoring, evaluation and research component will be a high priority during the recovery effort. Adjustments to on the ground actions in response to new information will be incorporated as we learn from our successes and failures. The challenges of salmon recovery are immense, particularly in the face of increasing human populations and heavy demand for precious resources such as sufficient clean water. It will be important to monitor the benefits and costs of completed actions and to work in a collaborative forum to tackle the hard issues to come.

3.2 Overview of Recovery Goals

A simplified way of looking at species recovery includes addressing those factors that lead to the species being listed. Section 4(a) (1) of the ESA and NMFS' implementing regulations (50 CFR part 424) set forth procedures for listing species. The Secretary of Commerce (Secretary) must determine, through the regulatory process, if a species is endangered or threatened because of any one or a combination of the following factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or human-made factors affecting its continued existence. NMFS has previously detailed the impacts of various factors contributing to the decline of Pacific salmon and *O. mykiss* (e.g., citations for ESU listing determinations;

NMFS 1997c, ‘‘Factors Contributing to the Decline of Chinook Salmon—An Addendum to the 1996 West Coast Steelhead Factors for Decline Report;’’ NMFS 1996a, ‘‘Factors for Decline—A Supplement to the Notice of Determination for West Coast Steelhead Under the Endangered Species Act’’). The Federal Register notices and technical reports concluded that all of the factors identified in section 4(a)(1) of the ESA have played a role in the decline of West Coast salmon and *O. mykiss* ESUs/DPSs. The Federal Register notices and technical reports provide a more detailed treatment of the relevant factors for decline for specific ESUs/DPSs. The following discussion briefly summarizes findings regarding the principal factors for decline across the range of West Coast salmon and *O. mykiss*. While these factors are treated in general terms, it is important to underscore that impacts from certain factors are more acute for specific ESUs/DPSs.

1. *The present or threatened destruction, modification, or curtailment of its habitat or range*: West Coast salmon and *O. mykiss* have experienced declines in abundance over the past several decades as a result of loss, damage or change to their natural environment. Water diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat and degraded remaining habitat. Forestry, agriculture, mining, and urbanization have degraded, simplified, and fragmented habitat. Studies indicate that in most western states, about 80 to 90 percent of the historical riparian habitat has been eliminated (Botkin et al. 1995). The destruction or modification of estuarine areas has resulted in the loss of important rearing and migration habitats. Losses of habitat complexity and habitat fragmentation have also contributed to the decline of West Coast salmonids. Sedimentation from extensive and intensive land use activities (e.g., forest practices, roads, livestock grazing, and urbanization) is recognized as a primary cause of habitat degradation throughout the range of West Coast salmon and *O. mykiss*.

   Water quality impairment that affects spawning, migration and rearing is a problem in many areas that were historically suitable rearing and spawning habitat. Summer stream temperature is the primary water quality problem for Mid-C steelhead, and many stream reaches are listed on the Clean Water Act (CWA) 303(d) list for water temperature. Contaminants such as insecticides and herbicides from agricultural run-off and heavy metals from mine waste are common in some areas of designated critical habitat for this DPS.

   Low summer streamflows are also a common characteristic affecting spawning, rearing, and migration. Withdrawal and storage of natural streamflow—and land use practices that reduced water storage on uplands, floodplains and riparian areas—have altered the natural pattern of flows over the seasons and caused inadequate flow, scouring flows, or other flow conditions that inhibit steelhead distribution and survival. Many stream reaches are over-appropriated under state water law at low summer flow, with more allocated water rights than existing streamflow conditions can support.
   Depending upon their natal watershed, adult and out-migrating juvenile steelhead from the Oregon portion of the Mid-Columbia River DPS encounter between one and four mainstem Columbia River dams migrating to and from the ocean. Hydroelectric development has modified natural flow regimes resulting in higher water temperatures,

changes in fish community structure, and increased travel time for migrating adults and juvenile salmonids. Physical features of dams such as turbines also kill migrating fish. The only substantial habitat blockages at present in this DPS are Pelton Dam on the Deschutes River and Condit Dam on the White Salmon River. However, smaller dams, impassable culverts, irrigation dams, and other small passage barriers occur throughout the region.

2. *Overutilization for commercial, recreational, scientific, or educational purposes*: Historically, salmon and *O. mykiss* were abundant in many western coastal and interior waters of the United States. These species have supported, and continue to support, important tribal, commercial and recreational fisheries throughout their range, contributing millions of dollars to numerous local economies, as well as providing important cultural and subsistence needs for Native Americans. Overfishing in the early days of European settlement led to the depletion of many stocks of salmonids, prior to extensive modifications and degradation of natural habitats. However, following the degradation of many west coast aquatic and riparian ecosystems, exploitation rates were higher than many populations could sustain. Therefore, harvest may have contributed to the further decline of some populations.

   Steelhead harvest or fishery impact occurs in Columbia River and tributaries sport fisheries, Columbia River Treaty Indian gillnet fisheries, Columbia River Treaty Indian subsistence fisheries, and tributary Treaty Indian subsistence fisheries. Landing records and coded wire tag analyses indicate that steelhead are not taken in significant numbers in any ocean fishery, apparently because of an offshore, high-seas distribution pattern. Non-Indian commercial fisheries for steelhead in the Columbia River have been prohibited beginning in 1975 and incidental impacts of non-Indian commercial fisheries for other species are minimal because no significant fisheries occur in the group A (see Life History section below) migration time frame.

   Columbia River sport fisheries above and below Bonneville Dam keep only marked (hatchery) fish since the late 1970's. Significant sport fisheries for steelhead between Bonneville Dam and the Deschutes River occur primarily from July through September when fish seek refuge from warm Columbia River temperatures in cool tributary mouths, primarily in Bonneville Reservoir. Steelhead are taken by treaty Indian fisheries in the Columbia River mainstem primarily in fall gillnet fisheries that target Chinook salmon from late August through October. Current steelhead harvest rates in fall treaty Indian fisheries are limited in number and through the use of large mesh gillnets, which target the larger fall Chinook. Small numbers of steelhead are also taken in various ceremonial and subsistence fisheries during the remainder of the year. These fisheries primarily occur by hook-and-line or from platforms with dip nets. Treaty Indian fisheries occur from Bonneville to McNary dams, but most of the effort is between Bonneville Dam and the Deschutes River mouth.

   Steelhead harvest or fishery impact also occurs in the Deschutes Basin sport and tribal dipnet fisheries (which occurs immediately below Sherars Falls in years when fall salmon runs are significant). The required release of wild fish, catch of many non-local fish, and

the reliance on catch record card data for catches above Sherars Falls make estimation of fishery impacts on natural-origin Deschutes River steelhead difficult.

3. *Disease or predation***:** Introductions of non-native species and habitat modifications have resulted in increased predator populations in numerous rivers and lakes. Predation by seabirds can influence the survival of juvenile salmon and *O. mykiss* in some locations. For example, it is estimated that Caspian terns (*Sterna caspia*) in the lower Columbia River and estuary consume approximately 13 percent of the outmigrating smolts reaching the estuary in some years (Collis et al. 2001). Other mainstem predation occurs from walleye (*Stizostedion Vitreum*) and California sea lions (*Zalophus californianus*) of juveniles and adults, respectively.

   Infectious disease is one of many factors that can influence adult and juvenile salmon and *O. mykiss* survival. In general, very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases. Native *O. mykiss* populations have co-evolved with specific communities of these organisms, but the widespread use of artificial propagation has introduced exotic organisms not historically present in a particular watershed. Habitat conditions such as low water flows and high temperatures can exacerbate susceptibility to infectious diseases.

4. *The inadequacy of existing regulatory mechanisms*: The ESA listings of salmon ESUs and *O. mykiss* DPSs have provided the incentive for numerous protective efforts. While many causes of decline in salmon ESUs and *O. mykiss* DPSs are being addressed (e.g., providing fish passage above artificial barriers), habitat degradation and destruction have been slowed but not prevented. The protective efforts are directed toward addressing the numerous factors that adversely impact Mid-C steelhead and its habitat — water quality and quantity, safe migration, riparian vegetation, food, predation dynamics and complex stream channels, and floodplain connectivity. These actions all will aid in improving these factors within the area of each project. The recovery planning process addresses the cumulative effects of these and other protective efforts, and any additional measures necessary to address the species' factors for decline and extinction risk.

5. *Other natural or manmade factors affecting its continued existence*: Variability in ocean and freshwater conditions can have profound impacts on the productivity of salmon and *O. mykiss* populations. Natural climatic conditions have at different times exacerbated or mitigated the problems associated with degraded and altered riverine and estuarine habitats.

   Widespread presence of hatchery fish throughout the DPS was also identified as contributing to declines in population abundance. Extensive hatchery programs have been implemented throughout the range of West Coast salmon and *O. mykiss*. The Umatilla and Deschutes river systems have ongoing hatchery production programs based on locally derived broodstock. The straying of hatchery steelhead from out-of-DPS production programs poses a significant threat to several steelhead populations in the DPS. Straying of out-of-basin hatchery fish into the Deschutes River has been identified as a chronic occurrence.

3.3 Description and Taxonomy

The March 25, 1999 (64 FR 14517) listing of Mid-Columbia River steelhead was developed in response to a biological review that concluded that summer steelhead in the Mid-Columbia River ESU were "likely to become endangered in the foreseeable future" (NMFS 1999). Protective regulations for Mid-C steelhead were issued under section 4(d) of the ESA on July 10, 2000 (65 FR 42422).

The most prominent factors leading to NMFS' conclusion that Mid-C steelhead were threatened included: (1) declines in abundance of wild steelhead populations, (2) levels of abundance well below historical levels, (3) large numbers of hatchery-origin steelhead entering the Deschutes River basin, and a lack of information regarding this phenomenon, (4) large numbers of hatchery steelhead relative to wild steelhead, and a general lack of information regarding the impacts of hatchery steelhead on wild steelhead populations throughout the region, (5) a lack of information regarding the interactions between resident rainbow trout and anadromous steelhead, and (6) habitat alterations in the region resulting in a loss of spawning and rearing habitat for steelhead, including habitat changes that have exterminated some steelhead runs (Busby et al. 1996; NMFS 1999).

The Mid-Columbia River steelhead ESU included all natural populations of steelhead in streams within the Columbia River basin from above the Wind River in Washington and the Hood River in Oregon upstream to, and including, the Yakima River in Washington, excluding steelhead from the Snake River Basin. It also included resident trout populations of *O. mykiss* below impassible barriers (natural and manmade) that co-occurred with anadromous population in the Mid-Columbia River steelhead ESU (69 FR 33101 June 14, 2004). However, in January 2006, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating steelhead-only Distinct Population Segments (DPSs). NMFS listed the Mid-Columbia River steelhead DPS as threatened on January 5, 2006 (71 FR 834). The Federal Register Notice contains a more complete explanation of this listing decision.

This recovery plan focuses on the anadromous from of *O. mykiss*. However, the strategic focus to restore natural ecological processes throughout the subbasins through habitat restoration and protection will provide productivity and capacity benefits for all *O. mykiss* life history forms. Protection and restoration of natural ecological processes will contribute significantly to restoring a natural balance among *O. mykiss* resident and anadromous life history forms.

Mid-C steelhead historically occupied nine major river systems within the states of Oregon and Washington on the east side of the Cascades Mountains (Figure 3-2) and numerous minor systems. These major tributaries to the Columbia River include the White Salmon, Fifteenmile Creek, Deschutes, John Day, Klickitat, Rock Creek, Umatilla, Walla Walla, and Yakima River systems. The John Day River of central Oregon probably represents the largest naturally spawning, native group of steelhead in the region.

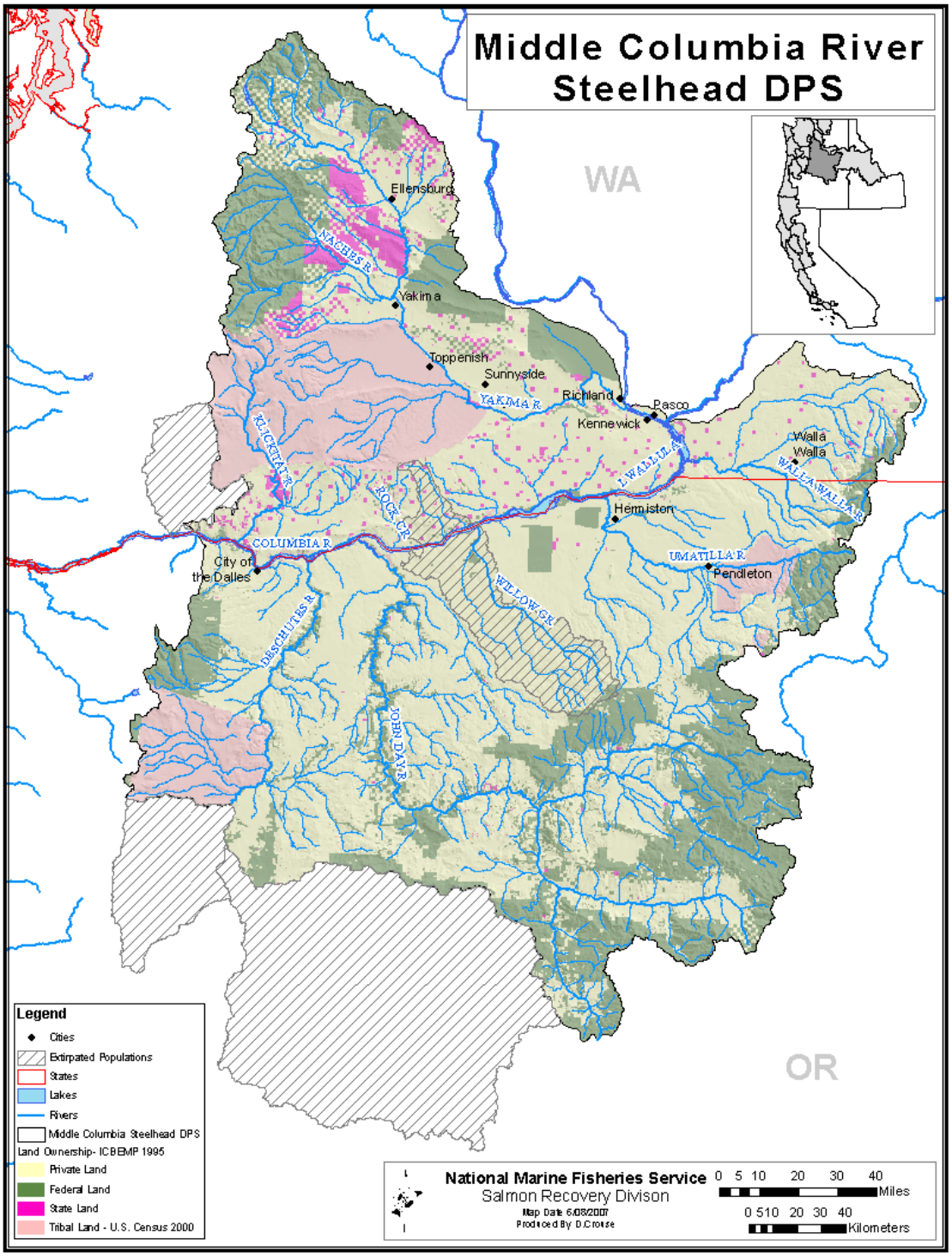


Figure 3-2. Geographic boundaries of the Middle Columbia River Steelhead DPS.

The Interior Columbia Basin Technical Recovery Team (ICTRT 2003) identified historical populations throughout the Interior Columbia River Basin (Figure 3-3). There are 17 extant populations. There are two extinct populations in the Cascades Eastern Slope Major Population

Group (MPG): the White Salmon River and Deschutes Crooked River above Pelton Dam, and one extinct population in the Umatilla/Walla Walla MPG: Willow Creek.

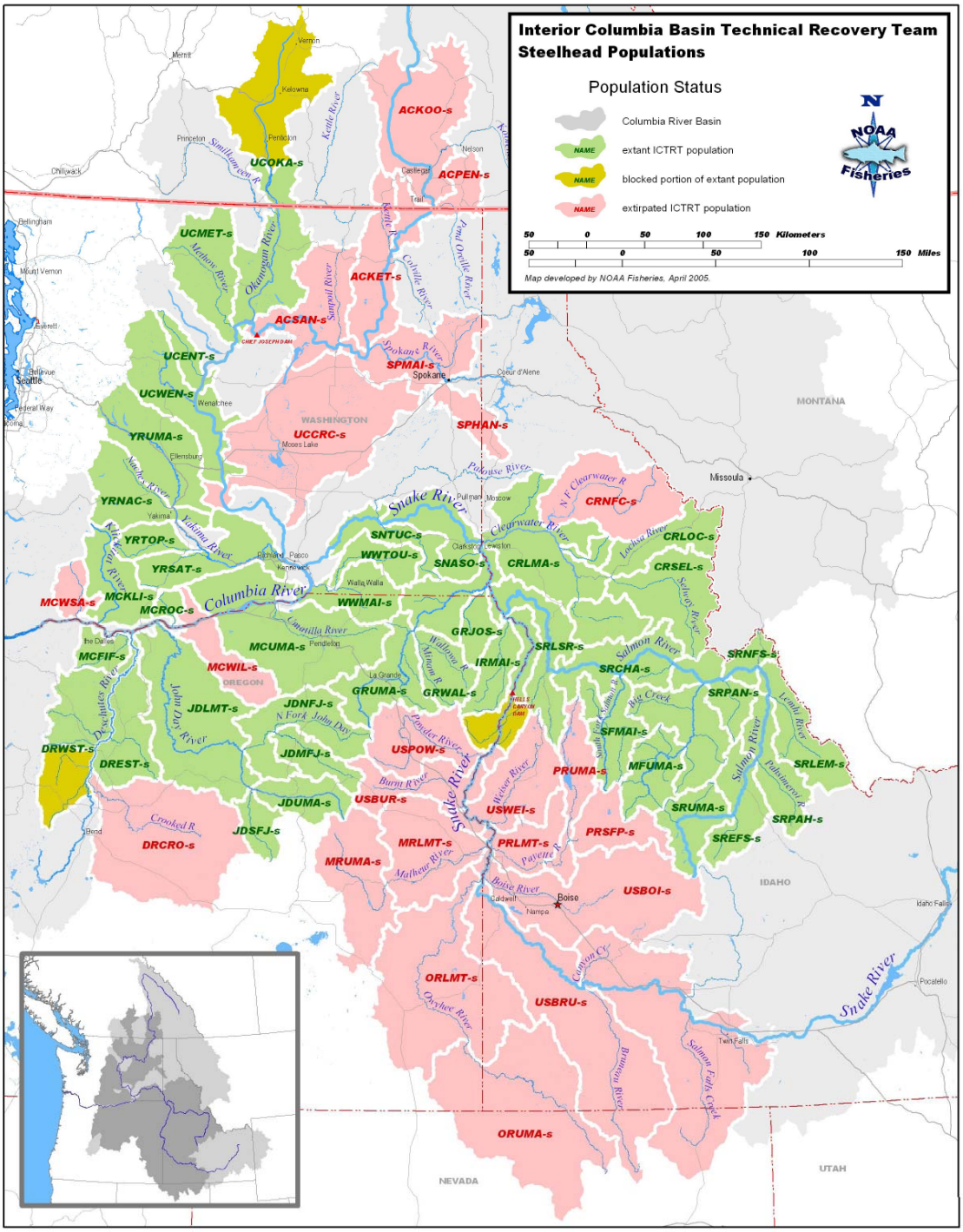


Figure 3-3. Interior Columbia River Basin steelhead populations including populations in the Middle Columbia River Steelhead DPS (ICTRT 2003).

Hatchery programs propagate steelhead in three populations and improve kelt (post spawned adult) survival in one population. No artificial programs produce the winter-run life history in the Klickitat River and Fifteenmile Creek populations. All of the DPS hatchery programs are designed to produce fish for harvest, although two are also implemented to augment the naturally spawning populations in the basins where the fish are released.

3.4 Life History

'Steelhead' is the name commonly applied to the anadromous form of the biological species *O. mykiss*. The present distribution of steelhead extends from Kamchatka in Asia, east to Alaska, and down to southern California (NMFS 1999c), although the historical range of *O. mykiss* extended at least to the Mexico border (Busby et al. 1996). *O. mykiss* exhibit perhaps the most complex suite of life history traits of any species of Pacific salmonid. They can be anadromous or freshwater residents (and under some circumstances, yield offspring of the opposite form). Those that are anadromous can spend up to seven years in fresh water before smoltification, and then spend up to three years in salt water before first spawning. This species can also spawn more than once (iteroparous), whereas all other species of Oncorhynchus except cutthroat trout (*O. clarki*) spawn once and then die (semelparous). The anadromous form of *O. mykiss* is presently under NMFS jurisdiction, while the resident freshwater forms, usually called "rainbow" or "redband" trout, are under the jurisdiction of the U.S. Fish and Wildlife Service.

Within the range of West Coast steelhead, spawning migrations occur throughout the year, with seasonal peaks of activity. In a given river basin there may be one or more peaks in migration activity; since these "runs" are usually named for the season in which the peak occurs, some rivers may have runs known as winter, spring, summer, or fall steelhead. For example, large rivers, such as the Columbia, Rogue, and Klamath rivers, have migrating adult steelhead at all times of the year. There are local variations in the names used to identify the seasonal runs of steelhead; in Northern California, some biologists have retained the use of the terms spring and fall steelhead to describe what others would call summer steelhead.

Steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry, and duration of spawning migration (Burgner et al. 1992). The "stream-maturing" type (summer steelhead in the Pacific Northwest and Northern California) enters fresh water in a sexually immature condition between May and October and requires several months to mature and spawn. The "ocean-maturing" type (winter steelhead in the Pacific Northwest and Northern California) enters fresh water between November and April with well-developed gonads and spawns shortly thereafter. In basins with both summer and winter steelhead runs, it appears that the summer run occurs where habitat is not fully utilized by the winter run or a seasonal hydrologic barrier, such as a waterfall, separates them. Summer steelhead usually spawn farther upstream than winter steelhead (Withler 1966, Roelofs 1983, Behnke 1992). Coastal streams are dominated by winter steelhead, whereas inland steelhead of the Columbia River Basin are almost exclusively summer steelhead. Winter steelhead may have been excluded from inland areas of the Columbia River Basin by Celilo Falls or by the considerable migration distance from the ocean. The Sacramento-San Joaquin River Basin may have historically had multiple runs of steelhead that probably included both ocean-maturing and stream-maturing stocks (CDFG 1995, McEwan and Jackson 1996). These steelhead are referred

to as winter steelhead by the California Department of Fish and Game (CDFG); however, some biologists call them fall steelhead (Cramer et. al 1995). Fifteenmile Creek and the Klickitat River support the populations of winter steelhead that are furthest inland in the Columbia Basin.

Inland summer steelhead of the Columbia River Basin, especially the Snake River Subbasin, are commonly referred to as either "A-run" or "B-run." These designations are based on a bimodal migration of adult steelhead at Bonneville Dam (235 km from the mouth of the Columbia River), and differences in age (1 versus 2 years in the ocean) and adult size observed among Snake River steelhead. It is unclear, however, to what degree the life history and body size differences observed upstream are correlated back to the groups forming the bimodal migration observed at Bonneville Dam. A-run steelhead are believed to occur throughout the steelhead-bearing streams of the Snake River Basin and the inland Columbia River. B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon rivers (IDFG 1994).

Life history characteristics for Mid-C steelhead are similar to those of other inland steelhead DPSs. Most fish smolt at two years and spend one to two years in salt water before reentering freshwater, where they may remain up to a year before spawning. All steelhead upstream of The Dalles Dam are summer-run fish that enter the Columbia River from June to August. Adult steelhead ascend mainstem rivers and their tributaries throughout the winter, spawning in the late winter and early spring. Fry emergence typically occurs between May and the end of June. A nonanadromous form of *O. mykiss* co-occurs with the anadromous form in this DPS; information suggests that the two forms may not be isolated reproductively.

3.5 Critical Habitat

Critical habitat was designated on February 16, 2000 [65 FR 7764], but vacated (undesignated) by court order on April 30, 2002. On September 2, 2005, NMFS published a final rule (70 FR 52630) to designate critical habitat for Mid-C steelhead and 12 other ESUs/DPSs of salmon and steelhead. The final rule took effect on January 2, 2006. The Critical Habitat Assessment Review Team (CHART) (NMFS 2004c) rated the conservation value of all 5th-field HUCs supporting populations of Mid-C steelhead.

Essential features of designated critical habitat include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water, velocity, space, and safe passage. These features also describe the habitat factors associated with viability for all ESUs and DPSs. The specific habitat requirements for each ESU or DPS differ by life history type and life stage.

Primary constituent elements (PCEs) consist of the physical and biological elements identified as essential to the conservation of the species in the documents identifying critical habitat (Table 3-1). Figure 3-4 depicts those streams designated critical habitat for Mid-C steelhead.

Table 3-1. Types of sites and essential physical and biological features designated as PCEs, and the life stage each PCE supports.

Site	Essential Physical and Biological Features	ESU Life Stage
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity and floodplain connectivity	Juvenile growth and mobility
	Water quality and forage	Juvenile development
	Natural cover[a]	Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover[b]	Juvenile and adult mobility and survival
Estuarine areas	Free of obstruction, water quality and quantity, and salinity	Juvenile and adult physiological transitions between salt and freshwater
	Natural cover,[a] forage,[b] and water quantity	Growth and maturation
Nearshore marine areas	Free of obstruction, water quality and quantity, natural cover,[a] and forage[b]	Growth and maturation, survival
Offshore marine areas	Water quality and forage[b]	Growth and maturation

[a] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

[b] Forage includes aquatic invertebrate and fish species that support growth and maturation.

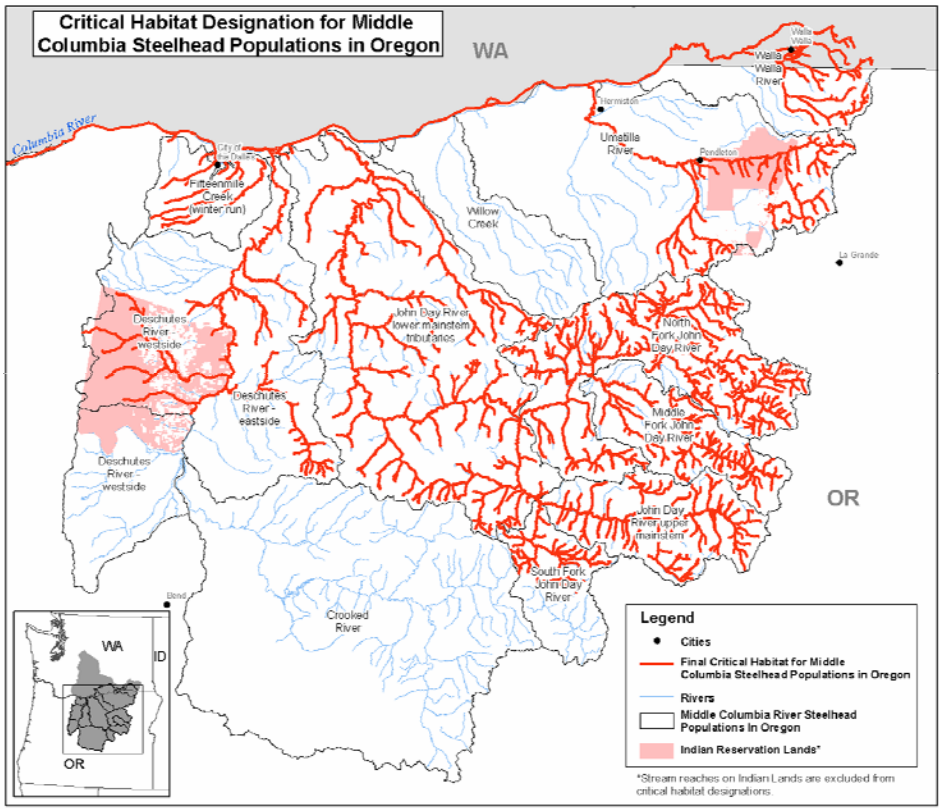


Figure 3-4. Critical habitat designated for salmon and steelhead in Oregon.

Section 4 DPS Structure

This section describes the biological hierarchical organization for the Mid-Columbia River Steelhead DPS, including major population groups and independent populations. It also discusses the characteristics that define the Mid-C steelhead populations in Oregon subbasins.

4.1 Steelhead Population Structure: A Biologically-Based Hierarchy

Steelhead organizational structure is hierarchical from the species level to a level below the population. The homing propensity, distribution across the landscape, and the diverse genetic, life history and morphological characteristics that evolve contribute significantly to the hierarchical structure and long-term persistence.

Recovery planning efforts focus on this biologically based hierarchy that spans DPSs, major groups, populations and substructure within populations, and reflects the apparent degree of connectivity between the fish in each of these hierarchical levels (Figure 4-1). Two levels in this hierarchy, the ESU or DPS and population, were formally defined for listing, delisting, and recovery planning purposes. The ICTRT identified an additional level in the hierarchy between the population and ESU levels. These three levels in the hierarchy are described below.

- **Evolutionarily Significant Unit or Distinct Population Segment:** Two criteria define a salmon ESU or steelhead DPS listed under the ESA: 1) it must be substantially reproductively isolated from other nonspecific units, and 2) it must represent an important component of the evolutionary legacy of the species (Waples 1991). ESUs and DPSs may contain multiple populations that are connected by some degree of migration, and hence may have broad geographic areas, transcending political borders.

- **Major Population Groups:** Within ESUs and DPSs, independent populations can be grouped into larger aggregates that share similar genetic, geographic (hydrographic and ecoregion), and/or habitat characteristics (ICTRT 2003). These "major groupings" are groups of populations that are isolated from one another over a longer time scale than that defining the individual populations, but which retain some degree of connectivity greater than that between ESUs or DPSs. The ICTRT defines this level in the hierarchy as Major Population Groups. These MPGs are analogous to “strata” as defined by the Lower Columbia-Upper Willamette TRT and “geographic regions” described by the Puget Sound TRT.

- **Independent Populations:** McElhany et al. (2000) defined an independent population as: *“…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a ‘substantial degree’ means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not*

substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."

Independent populations are the units that will be combined to form alternative recovery scenarios for MPG and DPS viability. Ultimately, the populations are the primary units of recovery actions.

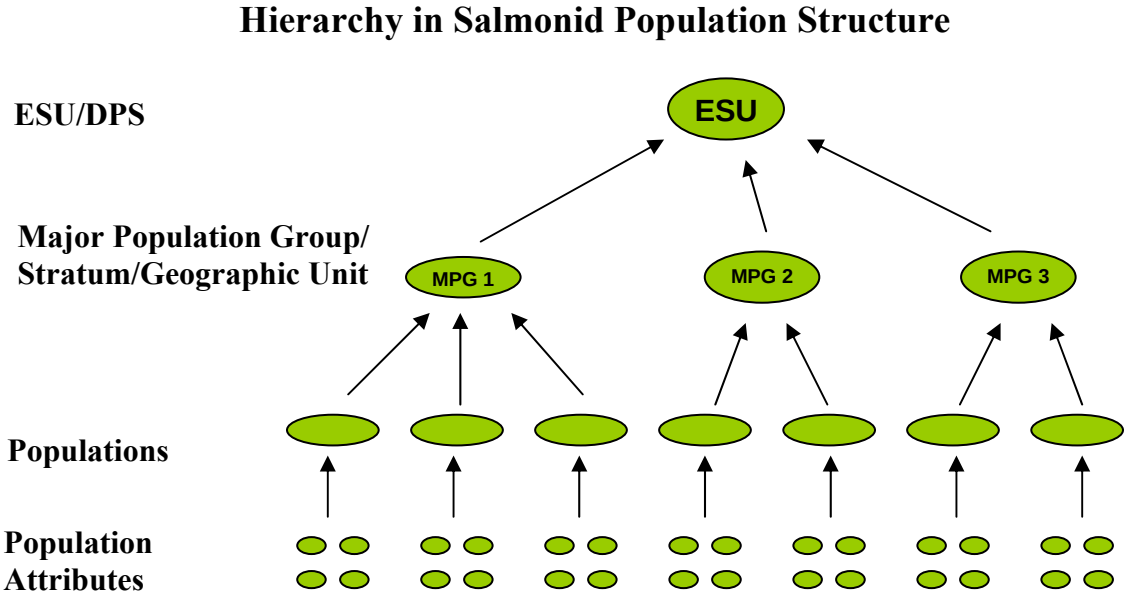


Figure 4-1. Hierarchical population structure within ESA-listed ESUs/DPSs, as identified by the TRTs.

4.1.1 Population Structure Adopted for Recovery Planning

The Oregon Department of Fish and Wildlife has adopted the DPS, Major Population Groups and population structure defined by the ICTRT for purposes of Mid-C steelhead recovery planning. These groups were defined based on genetic, geographic (hydrographic) and habitat considerations (ICTRT 2003) with guidance provided by the Viable Salmonid Populations document (McElhany et al. 2000).

Population Identification
As one of its first tasks in recovery planning, the ICTRT delineated independent populations within the listed ESUs in the Interior Columbia Basin, including those in the Mid-Columbia River steelhead DPS. This delineation of population boundaries is critical for effective conservation planning, since incorrect lumping or splitting of populations (or portions of populations) can provide an inaccurate picture of population status. Over- or underestimating the true status (Abundance/Productivity, Spatial Structure/Diversity) may lead to failed recovery efforts. Similarly, if two "true" populations are treated as a single unit, the status of one may mask the other, potentially leading to the loss of one of the populations (ICTRT 2003).

The ICTRT assessed a variety of information sources to delineate independent populations (ICTRT 2003). It initially classified major groups of populations within ESUs, and then identified independent populations within major groups. It used a variety of data types to define MPGs and independent populations; however, in no case was the entire array of desired information available to inform its decision process. It relied heavily on genetic information, distances between spawning areas related to dispersal (straying distance) as evidence of reproductive isolation, and habitat characteristics. Phenotypic (life history and morphological) characteristics were also considered for distinction at the population level. In addition, it considered two demographic factors. First, because the goal was to identify demographically independent populations, it examined the correlation in abundance time series between areas. Second, it considered historical population size in determining potential population capacity (ICTRT 2003).

Mid-Columbia River Steelhead DPS Populations

The Mid-Columbia River steelhead (*Onchorhynchus mykiss*) DPS includes all natural steelhead populations in streams within the Columbia River basin from above the Wind River in Washington and the Hood River in Oregon (exclusive), upstream to, and including, the Yakima River in Washington, excluding steelhead from the Snake River basin (71 FR 834 January 5, 2006; 64 FR 14517 March 25, 1999). Stream systems in the DPS include Rock Creek and the White Salmon, Klickitat, and Yakima rivers on the northern side of the Columbia and Fifteenmile Creek, and the Deschutes, John Day, Umatilla and Walla Walla rivers and Willow Creek on the southern side (Figure 4-2).

The ICTRT identified four Major Population Groups in the Mid-Columbia River steelhead DPS ─ Cascades Eastern Slope Tributaries, Yakima River, John Day River and Umatilla/Walla Walla Rivers (ICTRT 2003). Figure 4-3 shows these major population groups. Three of these major population groups contain Mid-C steelhead from Oregon tributaries and are addressed in this recovery plan.

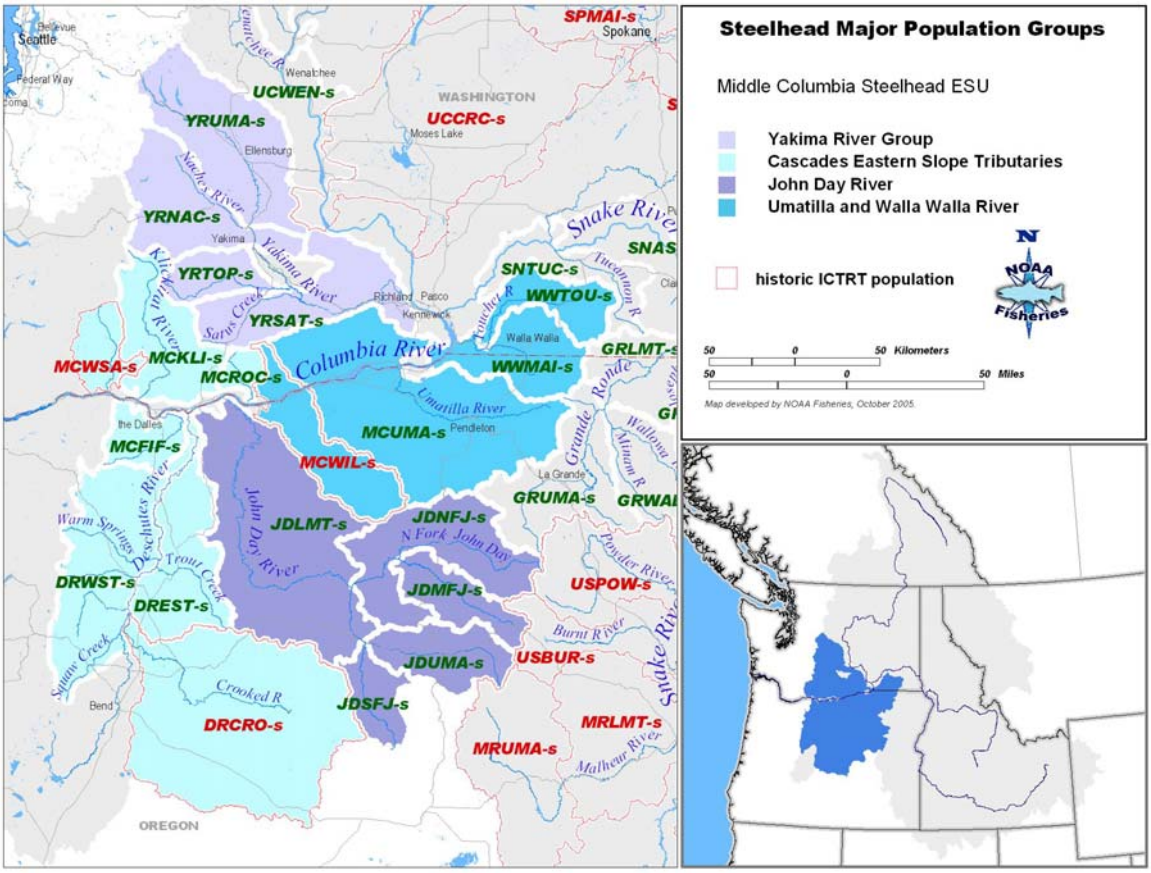


Figure 4-2. Middle Columbia River Steelhead DPS major population groups and populations.

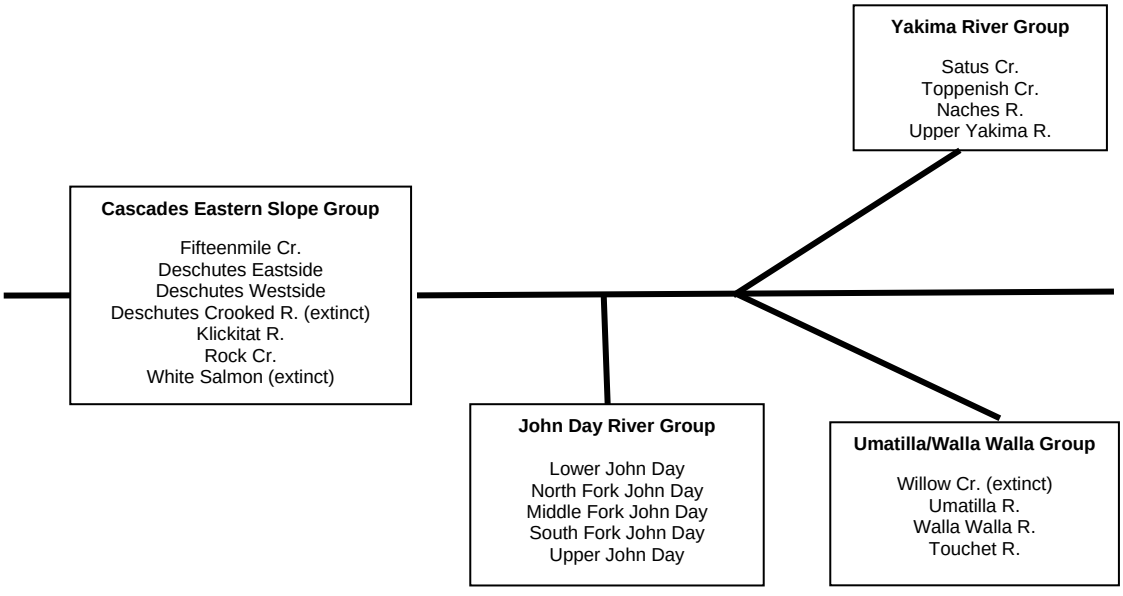


Figure 4-3. Major Population Groups and populations of the Middle Columbia River Steelhead DPS.

Together, the four major population groups in the DPS contain 17 extant and 3 extinct independent populations (ICTRT 2003). Subbasins on the Oregon side of the Columbia River historically supported 12 of the 20 populations in the Mid-Columbia River steelhead DPS. These 12 populations, the subject of this plan, include 10 extant populations: Fifteenmile Creek, Deschutes River Westside, Deschutes River Eastside, Lower Mainstem John Day, North Fork John Day, Upper Mainstem John Day, Middle Fork John Day, South Fork John Day, Umatilla River, and Walla Walla River; and 2 extinct populations: Deschutes/Crooked River and Willow Creek. Five extant populations and one extinct population of Mid-C steelhead reside on the Washington side of the Columbia River and are addressed in other recovery plans. Figure 4-4 shows the independent steelhead populations in the DPS.

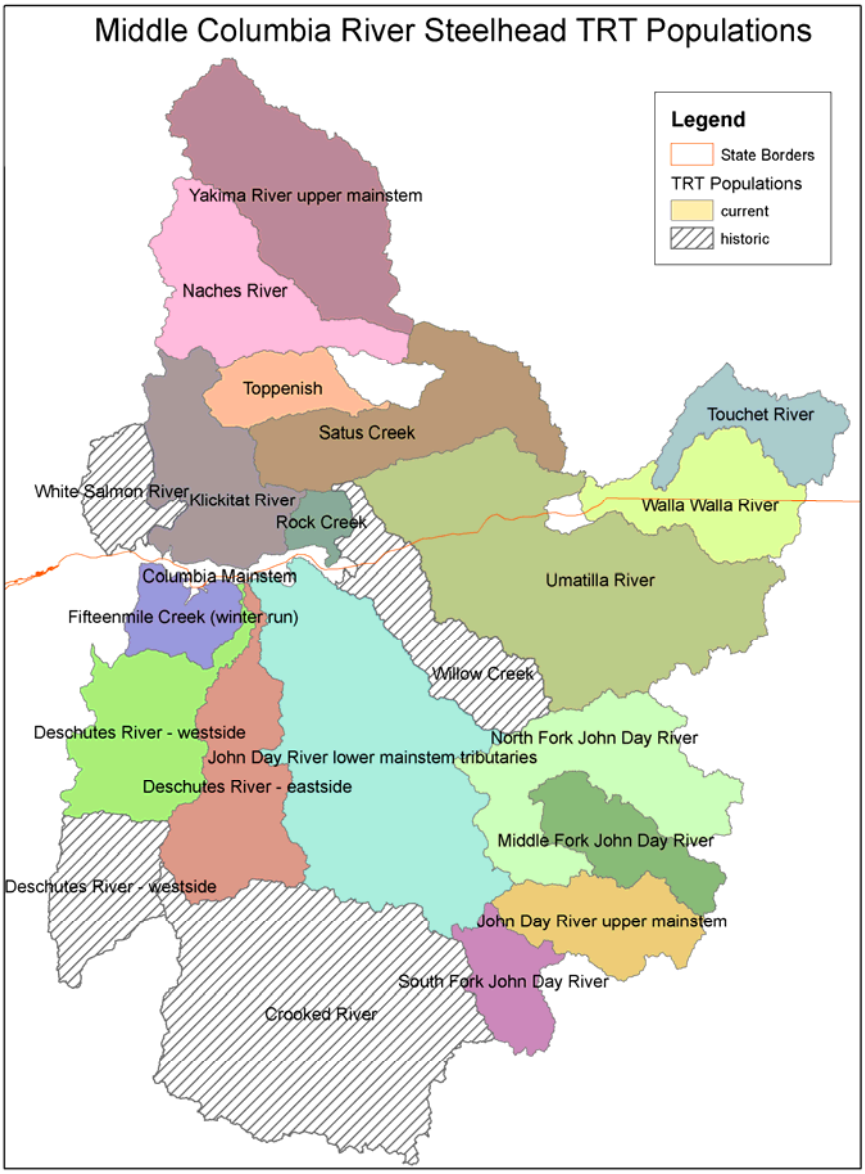


Figure 4-4. Independent populations within the Middle Columbia River Steelhead DPS.

The three major population groups that contain independent Mid-Columbia steelhead populations in Oregon subbasins are described below. These MPGs include the Cascades Eastern Slope Tributaries MPG, John Day River MPG and Walla Walla and Umatilla rivers MPG. Descriptions of the MPGs and independent populations summarize information provided in the ICTRT report *Independent Populations of Chinook, Steelhead, and Sockeye for Listed Evolutionarily Significant Units within the Interior Columbia River Domain* (ICTRT 2003) and the updated population delineation in the interior Columbia Basin memorandum (ICTRT May 11, 2005). Mid-C steelhead populations from Washington tributaries are not discussed in this document.

Cascades Eastern Slope Tributaries MPG

The Cascades Eastern Slope Tributaries MPG contains five extant populations and two extinct populations. Oregon subbasins support three of the extant populations ─ Deschutes River Westside, Deschutes River Eastside, and Fifteenmile Creek ― and historically supported the extinct Deschutes/Crooked River. Populations in the Cascades Eastern Slope Tributaries MPG are united primarily by geographic proximity. The habitats they occupy are diverse, but the constituent rivers generally drain the eastern slope of the Cascades and the dry Columbia Plateau. The MPG supports summer and winter run life history forms of steelhead.

1. *Fifteenmile Creek*: This population occupies Fifteenmile Creek and its tributaries, Fivemile, Eightmile and Ramsey creeks. It also includes five drainages outside of the Fifteenmile Creek watershed ― Threemile, Mill, Chenoweth, Mosier, and Rock creeks ― that flow directly into the Columbia River. The population is moderately segregated from other populations (22 km from the Klickitat and 37 km from the nearest spawning in the Deschutes River), and occupies somewhat different habitat. Fifteenmile Creek steelhead are exclusively winter run fish and are considered the easternmost distribution of winter steelhead in the Columbia basin. These characteristics, coupled with genetic differentiation and capacity, lead to designation as an independent population.

2. *Deschutes River Eastside*: The Deschutes River Eastside summer steelhead population occupies the mainstem Deschutes River from its mouth to the confluence of Trout Creek, and the tributaries entering the Deschutes from the east: Buck Hollow, Bakeoven, and Trout Creeks. Because of uncertainty concerning the relationship of mainstem spawners in the Deschutes River and tributaries, mainstem reaches were grouped with their respective tributary population. The population is separated from the Fifteenmile Creek population by geographic distance (37 km) and run timing (Fifteenmile steelhead are exclusively winter run fish), and from the Deschutes River Westside population because of significant habitat and life history differences. Eastside tributaries drain drier, lower elevation areas than the Westside tributaries, resulting in quite different flow and temperature patterns.

3. *Deschutes River Westside*: The Deschutes River Westside summer steelhead population boundaries encompass the mainstem Deschutes River from the mouth of Trout Creek upstream to Big Falls (current upstream barrier to anadromous fish), and tributaries entering the Deschutes from the west, including the Warm Springs River, Shitike Creek, Whychus Creek and the Metolius River. The current occupied area only includes the

mainstem from the mouth of Trout Creek upstream to Pelton Dam, the Warm Springs River, and Shitike Creek. The remaining area is blocked by the Pelton-Round Butte Complex. The population is separated from the eastside population based on habitat and life history characteristics. Nearly 50% of the habitat resides in the Ponderosa Pine-Bitterbrush Woodland ecoregion. None of the habitat in the Eastside population resides in this ecoregion.

4. *Deschutes Crooked River*: This historical population once occupied the Crooked River drainage, a major watershed in the Deschutes basin. The populations is now extinct as Pelton Dam, a hydroelectric dam at RM 100 on the Deschutes River, blocks all anadromous fish passage. The population boundaries include Crooked River and its tributaries. The population was designated based on historical capacity and distance from other populations. Ochoco Dam built on Ochoco Creek (RM 10) in 1922 and Bowman Dam built on the Crooked River mainstem in 1961 (RM 70) without passage facilities blocked migration to the upper portion of the Basin (Nehlsen 1995). Passage was abandoned at the Pelton-Round Butte Complex in 1968, and anadromous fish passage is now blocked at the Pelton Reregulating Dam (RM 100). There is a current management agreement and plan to re-establish steelhead production within the Crooked River population boundaries up to Ochoco and Bowman dams.

   There is currently (March 2007) a barrier at Opal Springs Dam on the Crooked River immediately upstream from Lake Billy Chinook (LBC) that will need to have safe upstream passage before any production of steelhead is possible within the Crooked River Basin. Opal Springs Dam is not scheduled for federal relicensing for many years. However, state and federal biologists are currently working with the licensee, Deschutes Valley Water District, to work out a plan to provide upstream passage.

John Day River MPG

The ICTRT defined the John Day River MPG as a major grouping based primarily on basin topography and distance from other MPGs. The MPG covers Oregon's John Day River drainage. It is one of the few remaining summer steelhead groups in the Interior Columbia Basin that has had no intentional influence from introduced hatchery steelhead and that has recently been classified as strong or healthy (Huntington et al.1994, Lee et al.1997). The ICTRT identified five populations in this MPG based on genetic information, demographic correlations, and habitat/ecoregion data. Spawning areas are widely distributed across tributary and mainstem habitats.

1. *Lower Mainstem John Day River*: This summer steelhead population includes tributaries to the John Day River downstream of the South Fork John Day River. This widespread population is the most differentiated ecologically from other populations, occupying the lower, drier Columbia Plateau ecoregion. Habitat divergence and distance to other populations are the primary factors in delineating this population.

2. *North Fork John Day River*: The North Fork summer steelhead population occupies the highest elevation, wettest area in the John Day basin. Population boundaries include the main stem and tributaries of the North Fork John Day River. The ICTRT defined the

population based on habitat characteristics, basin topography, and demographic patterns. The population also encompasses sufficient habitat to support an independent population. Chilcote (2001) found that the upper North Fork index count was the most divergent of the John Day stocks, indicating demographic independence.

3. *Middle Fork John Day River*: This summer steelhead population occupies the Middle Fork John Day River and all its tributaries. Spawning areas in the Middle Fork John Day River are separated substantially from all other spawning areas, except for those in the North Fork John Day. The distance between spawning habitat in this population and others combined with habitat differences between this population and the North Fork population, as well as general basin topography, led to independent population designation.

4. *South Fork John Day River*: This summer steelhead population occupies the South Fork John Day River drainage. Genetic data from South Fork John Day River *O. mykiss* samples, which likely includes the anadromous form, indicate that the population is differentiated from those in other parts of the John Day (Currens et al. 1985). This independent population was defined based on genetic information and basin topography.

5. *Upper Mainstem John Day River*: The Upper Mainstem John Day River summer steelhead population includes the mainstem John Day River and tributaries upstream from the South Fork. It is separated from the lower mainstem based on habitat differences, and from the South Fork because of topography.

Walla Walla and Umatilla Rivers MPG

The Walla Walla and Umatilla rivers form a major grouping based on shared ecological characteristics and geographic proximity. They both drain the northwestern slopes of the Blue Mountains, with lower reaches in the warmer, drier habitats of the Columbia Plateau. Within this major group, genetic information, distance between spawning aggregates and ecoregional classifications contributed to ICTRT population delineations.

1. *Umatilla River*: The Umatilla River and its tributaries are considered an independent population. Both genetic analysis (Narum and Powell 2002) and distance from other populations supports separation of this subbasin from the Walla Walla River. There is little genetic differentiation between areas within the Umatilla River subbasin and substantial connectivity between spawning areas in the subbasin.

2. *Walla Walla River*: The Walla Walla River and its tributaries (except the Touchet River) are designated as an independent population. One major tributary to the Walla Walla River, the Touchet River, was identified as a separate population. Several genetic analyses indicate that *O. mykiss* in the Touchet River are genetically distinct from other *O. mykiss* in the Walla Walla basin (Currens 1985, Currens 1997, Narum et al. 2004, Kassler et al. in review). In addition, spawners in the mainstem Walla Walla River and its tributaries are geographically distant (101 km) from those in the Touchet and those in the Umatilla River.

3. *Touchet River*: The ICTRT identified the Touchet River, which flows into the Walla Walla River, as an independent population based on genetic and geographic separation.

4. *Willow Creek*: Willow Creek is an extinct population. It was designated as an independent population based on geographic distance from other populations and capacity sufficient to support an independent population.

Section 5 Desired Status
Delisting and Broad Sense Recovery

Under the ESA, a species no longer requires protection when it is no longer in danger of extinction or likely to become endangered within the foreseeable future based on evaluation of the listing factors specified in ESA Section 4(a)(1). To remove the Mid-Columbia River Steelhead DPS from the Federal ESA list, NMFS must determine that the DPS, as evaluated under the ESA listing factors, is no longer likely to become endangered. Any new factors identified since listing must also be addressed to ensure that the species no longer requires protection as a threatened species.

The desired status for Oregon's steelhead populations in the Mid-Columbia River steelhead DPS is two-fold. First, the populations must reach desired levels of biological viability to support removal of the DPS from the threatened and endangered species list. Second, the State of Oregon and the Mid-C Sounding Board seek to rebuild the populations to provide for sustainable fisheries and other ecological, cultural and social benefits. Broader than the definition of delisting provided by the ESA, these broad sense goals incorporate many of the traditional uses, as well as rural and Native American values, deemed important in the Pacific Northwest.

This section identifies the biological viability levels and criteria Oregon Mid-C steelhead populations need to achieve to support delisting of the DPS. It discusses the approach used by the ICTRT (2007) to define these levels and the viability criteria that we applied to assess viability characteristics for each population, MPG, and the DPS. It also describes our broad sense recovery goal and objectives for the Oregon portion of the Mid-Columbia River steelhead DPS.

5.1 Delisting Goal and Criteria

Our primary goal is to support removal of the Mid-C steelhead DPS from the threatened and endangered species list. This requires that the populations must reach the levels of biological viability defined by the ICTRT and adopted by the State of Oregon in this plan as delisting criteria. In the context of recovery, delisting criteria and viability criteria are considered synonymous. Achieving ICTRT biological viability status at the population and MPG levels is needed before the DPS can be considered at low risk of extinction and a candidate for delisting.

5.1.1 Overall Approach

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). The recovery criteria comprise the core standards that NMFS believes will lead to conditions upon which the decision to de-list a species will be based. The ESA's listing factors, and not the recovery plan, are the legal basis for making de-listing decisions.

One of the main tasks assigned to the NMFS's technical recovery teams for recovery planning was to recommend biologically based viability criteria for application to salmon and steelhead ESUs/DPSs listed under the ESA. Viability criteria identify characteristics and conditions that, when met, would describe viable populations and a viable ESU or DPS that no longer warrants listing. Viability criteria identify the metrics and thresholds that will be used to determine the status of a population and the viability risk.

The ICTRT's approach to recovery is based on guidance from the NMFS Technical Memorandum *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units (*McElhany et al. 2000). This memorandum provides general direction for setting viability objectives at the ESU and component population levels. Viable salmonid population (VSP) guidelines provided by McElhany et al. (2000) address four major considerations: abundance, productivity, spatial structure and diversity. ESU or DPS level viability criteria consider the appropriate distribution and characteristics of component populations to maintain a viable ESU or DPS in the face of longer-term ecological and evolutionary processes. The Independent Scientific Advisory Board (ISAB 2007b) recently reviewed the ICTRT criteria and concluded "The proposed criteria are based on a well-reasoned and well-supported set of scientific principles and are laid out in a relatively transparent fashion with clear guidelines and examples of their application. The general approach employed by the ICTRT and the underlying understanding of conservation biology and salmon biology are scientifically defensible with no apparent conceptual gaps that might negate the defensibility of the approach."

The ICTRT's approach is consistent with related applications by the Puget Sound and Lower Columbia/Willamette TRTs and the Upper Columbia QAR, and the review of specific information for listed Interior Columbia ESU and DPS populations. The general approach identified for viability criteria has five essential elements:

Stratified Approach: Life history and ecological complexity that historically existed should have a high probability of persistence. The ICTRT stratified the Mid-Columbia River steelhead DPS into groups based on ecoregion characteristics (Eastern Cascades, Columbia plateau, John Day and Yakima), life history types (summer, winter, and summer/winter) and other geographic and genetic considerations.

Viable Populations: Some individual populations within a MPG should have persistence probabilities consistent with a high probability of MPG persistence. The ICTRT defined high persistence probability based on the presence of at least two or one-half of historical populations, whichever is greater, with a negligible risk of extinction.

Representative Populations: Representative populations need to achieve viability criteria or be maintained, but not every historical population needs to meet viability criteria. Viable combinations of populations should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and dispersed populations that minimize susceptibility to catastrophic events.

Non-deterioration: No population should be allowed to deteriorate until DPS recovery is assured, and all extant populations must be maintained. The ICTRT provided specific

criteria for maintained population status. Current populations and subpopulation structure must be preserved. Recovery measures will be needed in most areas to stop further decline and offset the effects of future impacts.

Safety Factors: Higher levels of recovery should be attempted in more populations than the minimum needed to achieve DPS viability because not all attempts will be successful. Recovery efforts should target all populations, and more than the minimum population viability levels thought to ensure viability. Some populations should be highly viable.

During recovery planning, the ICTRT defined biological viability objectives at the DPS, MPG, and component population levels (McClure et al. 2003). Assessments of viability at these different levels follow guidelines and approaches recommended by the ICTRT. The ICTRT's ESU/DPS-level viability criteria are designed to assess risk for Abundance/Productivity and Spatial Structure/Diversity at the population level. Assessments are then rolled-up to the MPG and ESU levels.

5.1.2 Independent Population-level Viability Criteria

Guidelines for population-level viability (McElhany et al. 2000) state that a viable population should be large enough to:

1. have high probability of surviving environmental variation observed in the past and expected in the future;
2. be resilient to environmental and anthropogenic disturbances;
3. maintain genetic diversity; and,
4. support/provide ecosystem functions.

To address these guidelines, the ICTRT grouped specific population level criteria into two categories: measures addressing abundance and productivity, and measures addressing spatial structure/diversity considerations. It also developed a framework for compiling an aggregate risk score for a population based on the results of applying the individual criteria.

Population Abundance and Productivity

These two population performance characteristics are linked to drive extinction risk. Abundance refers to the average number of spawners in a population over a generation or more. Productivity, or population growth rate, refers to the performance of the population over time in terms of recruits produced per spawner.

Viable populations should demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater that 1.0 to allow the population to rapidly return to abundance target levels. Following guidelines from McElhany et al. (2000), the ICTRT identified the following objective for population abundance and productivity:

Abundance should be high enough that 1) in combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent historical patterns of

environmental variability; 2) compensatory processes provide resilience to the effects of short-term perturbations; and, 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns).

The ICTRT used the Viability Curve concept (McElhaney et al. 2003) as a framework for defining population specific abundance and productivity criteria. A viability curve describes those combinations of abundance and productivity that yield a particular extinction risk threshold. The two parameters are linked relative to extinction risks associated with environmental variability. This approach recognizes that relatively large populations are more resilient in the face of year-to-year variability in overall survival rates than smaller populations. Populations with relatively high intrinsic productivity ─ the expected ratio of spawners to their parent spawners at low levels of spawner abundance ─ are also more robust at a given level of abundance than populations with lower intrinsic productivity. Combinations of abundance and productivity are characterized by viability curves that represent specific extinction risks. Table 5-1 shows combinations of abundance and productivity that represent the 5% extinction risk viability curves for Mid-C steelhead (ICTRT 2007).

Table 5-1. Mid-Columbia River steelhead population viability curves in tabular format (return per spawner and population growth rate versions)[a] (ICTRT 2007).

Middle Columbia Steelhead Growth Rate (S/S)	Spawner to Spawner Measure Minimum Abundance by Population Size Categories				Population Growth Rate (Lambda) Measure Minimum Abundance by Population Size Categories				
	Basic	*Intermediate*	*Large*	*Very Large*	*Population Growth Rate*	*Basic*	*Intermediate*	*Large*	*Very Large*
1.1	5650	5650	5650	5650	**1.02**	48000	48000	48000	48000
1.125	4200	4200	4200	4200	**1.04**	15400	15400	15400	15400
1.13	3900	3900	3900	3900	**1.06**	6600	6600	6600	6600
1.15	3300	3300	3300	3300	**1.08**	3950	3950	3950	3950
1.175	2500	2500	2500	2500	**1.1**	2300	2300	2300	2300
1.2	2050	2050	2050	2250	**1.104**	2000	2000	2000	2250
1.25	1550	1550	1550	2250	**1.12**	1400	1400	1500	2250
1.3	1200	1200	1500	2250	**1.14**	1050	1050	1500	2250
1.35	1000	1000	1500	2250	**1.145**	1000	1000	1500	2250
1.4	800	1000	1500	2250	**1.16**	830	1000	1500	2250
1.45	660	1000	1500	2250	**1.18**	580	1000	1500	2250
1.5	570	1000	1500	2250	**1.2**	510	1000	1500	2250
1.55	520	1000	1500	2250	**1.21**	500	1000	1500	2250
1.6	500	1000	1500	2250	**1.22**	500	1000	1500	2250
1.65	500	1000	1500	2250	**1.24**	500	1000	1500	2250
1.7	500	1000	1500	2250	**1.26**	500	1000	1500	2250
1.75	500	1000	1500	2250	**1.28**	500	1000	1500	2250
1.8	500	1000	1500	2250	**1.3**	500	1000	1500	2250
1.9	500	1000	1500	2250					
2	500	1000	1500	2250					
2.1	500	1000	1500	2250					

[a] Combinations of abundance and productivity exceeding these combinations would have a projected extinction risk of less than 5% in 100 years, assuming continuation of recent (1978-present) variation in return rates. Spawner to spawner estimates generated using Hockey-Stick recruitment function and average variance (0.18), autocorrelation (0.74) and age structure (0.03 age 3; 0.46 age 4; 0.43 age 5; 0.04 age 6) for populations in the ESU. Population growth rate based estimates generated using average running sums based variance (0.17) for ESU populations.

Methodology and Analysis

The ICTRT developed viability curves representing 1%, 5%, and 25% extinction risk. Populations were grouped into four size categories ― Basic, Intermediate, Large or Very Large ― based on historical capacity, represented by the weighted intrinsic potential area within the population boundaries. The team developed a model to calculate the intrinsic spawning habitat

potential within defined populations. This approach quantified potential habitat based on the relationship of spawning use, landscape characteristics, and stream structure. A Geographic Information System (GIS) was used to compile ecological data, and for model development and output. Datasets describing spawning distribution, geomorphological features and instream habitat characteristics were crucial in developing the relationships. After spatial data acquisition, model parameters were formulated by comparing mapped salmon and steelhead spawning distribution to stream physiography and adjacent landforms.

In general, the ICTRT used spawning and habitat surveys to describe a species spatial structure by locality and density. Additionally, where site specific spawning locations were not available, we used general salmonid distributional GIS data produced by state agencies. The team then evaluated the mapped distributions against stream attributes and spatially coincident landscape features calculated from common spatial data themes. These included United States Geological Service (USGS) digital elevation models, the National Hydrography Dataset (NHD), soil data from the Natural Resources Conservation Service (NRCS), and climatic data from the National Climatic Data Center (NCDC). The 1:100,000 scale NHD layer was subdivided into a continuous series of 200-meter reaches, and this became the basic analysis unit. Using information modeled from the digital elevation models, NCDC precipitation grids, and NHD data, the ICTRT computed stream gradient, wetted and bankful width, and channel confinement, and then assigned this information to each 200-meter segment within the stream network. These attributes were concentrated into groups representing all observed combinations, which included 4 width classes, 6 gradient classes, and 3 confinement classes. Each discrete category was assessed by using statistical methods to compare the relative density of spawners observed within each group. Each habitat class was then assigned a rating of "high", "moderate", "low", or "none" in regards to spawning habitat potential (Table 5-2).

Two additional modifiers were applied to the habitat classes described in Table 5-2. First, there were some instances where stream width did not adequately address flow conditions. We found that certain streams that met general size requirements did not have appropriate flow parameters. Therefore, we assigned NHD stream velocities to our reach level data (200-meter segments) and compared these values to salmon and steelhead distributions. Where velocities fell below or above values observed within spawning locations we dropped intrinsic habitat ratings to "low." Our second qualifier incorporated sedimentation. Again, we observed streams where "moderate" or "high" intrinsic reaches (those with preferred widths, gradients, and confinement) were limited by natural environmental features. Soil erodibility was found to exhibit a negative relationship with spawning preferences. Generally, low gradient reaches within highly erodible soil complexes contain a greater potential for fine particle deposition, and hence poor spawning substrates. We identified low gradient reaches from our reach coverage and highly erodible soils from NRCS soils data. Calculations were also developed to assign mean soil erodibility to each 200-meter segment for the contributing watershed. From these assessments, we dropped low gradient reaches within highly erodible soils to a "low" intrinsic spawning potential. From the analyses described above , the ICTRT generated similar categories for all stream segments within the Interior Columbia ESUs/DPSs and assigned their corresponding habitat ratings. Reach length and width values were used to compute habitat area for all streams and we weighted the values by intrinsic spawning potential, so that "good" = (area * 1.0), "moderate" = (area * 0.5), "low" = (area * 0.25), and "none" = (area * 0.0). The ICTRT identified areas above

natural barriers and assigned these reaches a rating of "none." Natural barriers were identified through surveys from field biologists and gradient breaks computed from the DEM. Once calculated, the ICTRT summarized the weighted stream area for each population and generated size categories based on these values.

The ICTRT analyzed how weighted habitat was aggregated within populations, and labeled reaches with continuous high and moderate ratings as spawning branches. A spawning branch was defined as a stream reach with enough habitat to support 50 spawners. The accumulation of branches within populations then became the basis for defining major spawning areas (MaSAs). It also developed a process for aggregating MaSAs by evaluating the continuity of branch habitat and the spatial composition of stream junctions. A MaSA was required to have enough weighted habitat to support 500 spawners. MaSAs are an important habitat unit for assessing ecological complexity within populations, and for the spatial structure/diversity viability assessment.

Table 5-2. Habitat classes showing spawning potential by steelhead and Chinook. BF=Bankfull Width.

Habitat Factors			**Rating**	**Rating**
Stream Width	**Gradient**	**Valley Width**	**Steelhead**	**Chinook**
<3.7 m (chin) WETTED	***0 to .5***	*confined (<= 4x BF)*	**None**	**None**
<3.8 m (sthd) BANKFULL		*20x > BF > 4x*	**None**	**None**
		> 20x BF	**None**	**None**
	.5 to 1.5	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
	1.5 to 4.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
	4.0 to 7.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
	7.0 to 15.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
	>15.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
3.8 to 25 m	***0 to .5***	*confined (<= 4x BF)*	**None**	**Medium**
		20x > BF > 4x	**Medium**	**High**
		> 20x BF	**Medium**	**High**
	.5 to 1.5	*confined (<= 4x BF)*	**Low**	**Low**
		20x > BF > 4x	**High**	**Medium**

Habitat Factors Stream Width	Gradient	Valley Width	Rating Steelhead	Rating Chinook
		> 20x BF	**High**	**High**
	1.5 to 4.0	*confined (<= 4x BF)*	**Low**	**Low**
		20x > BF > 4x	**High**	**Low**
		> 20x BF	**High**	**Medium**
	4.0 to 7.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**Low**	**Low**
		> 20x BF	**Low**	**Low**
	7.0 to 15.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
	>15.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**
		> 20x BF	**None**	**None**
25 to 50m	***0 to .5***	*confined (<= 4x BF)*	**Low**	**None**
		> 4x BF	**Medium**	**Medium**
	.5 to 1.5	*confined (<= 4x BF)*	**Low**	**None**
		> 4x BF	**Medium**	**None**
	1.5 to 4.0	*confined (<= 4x BF)*	**Low**	**None**
		20x > BF > 4x	**Medium**	**None**
	4.0 to 7.0	*confined (<= 4x BF)*	**None**	**None**
		> 4x BF	**None**	**None**
	7.0 to 15.0	*confined (<= 4x BF)*	**None**	**None**
		> 4x BF	**None**	**None**
	>15.0	*confined (<= 4x BF)*	**None**	**None**
		> 4x BF	**None**	**None**
greater than 50m wetted	***0 to .5***	*confined (<= 4x BF)*	**Low**	**None**
		20x > BF > 4x	**None**	**None**
	.5 to 1.5	*confined (<= 4x BF)*	**Low**	**None**
		20x > BF > 4x	**None**	**None**
	1.5 to 4.0	*confined (<= 4x BF)*	**Low**	**None**
		20x > BF > 4x	**None**	**None**
	4.0 to 7.0	*confined (<= 4x BF)*	**Low**	**None**
		20x > BF > 4x	**None**	**None**
	7.0 to 15.0	*confined (<= 4x BF)*	**None**	**None**

Habitat Factors Stream Width	Gradient	Valley Width	Rating Steelhead	Rating Chinook
		20x > BF > 4x	**None**	**None**
	>15.0	*confined (<= 4x BF)*	**None**	**None**
		20x > BF > 4x	**None**	**None**

The ICTRT determined that abundance levels below 500 individuals for any population would pose unacceptable risk for inbreeding depression and other genetic concerns (ICTRT 2007), and established a minimum abundance threshold of 500 individuals for the basic size populations. Higher spawning threshold sizes were established incrementally for the three larger population sizes. Viability curves for all four size categories were truncated at the minimum abundance threshold level. Table 5-1 shows the combination of abundance and productivity values for all four size categories that yield a 5% risk of extinction. Populations were also categorized by their historical spatial distribution pattern and complexity. Table 5-3 shows population characteristics, spatial complexity designation, minimum abundance thresholds, and minimum productivity at threshold escapement needed to achieve a 95% probability of persistence over 100 years.

Table 5-3. Population characteristics and minimum abundance and productivity (at the threshold abundance level) values that represent levels needed to achieve a 95% probability of persistence over 100 years for Mid-Columbia steelhead populations in Oregon.

Population	Extant/ Extinct	Life History	Size	Spatial Category	Threshold[a] Abundance	Minimum Productivity
Cascades Eastern Slope Tributaries MPG						
Fifteenmile Creek	Extant	Winter	Basic	C-Trellis	500	1.56
Deschutes River Eastside	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35
Deschutes River Westside	Extant	Summer	Large (Inter.)[b]	B-Dendritic	1,500 (1,000)	1.26 (1.35)
Deschutes Crooked River	Extinct	Summer	Very Large	B-Dendritic	2,250	1.19
John Day River MPG						
Lower Mainstem John Day River	Extant	Summer	Very Large	B-Dendritic	2,250	1.19
North Fork John Day River	Extant	Summer	Large	B-Dendritic	1,500	1.26
Middle Fork John Day River	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35
South Fork John Day River	Extant	Summer	Basic	B-Dendritic	500	1.56
Upper Mainstem John Day River	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35
Umatilla/Walla Walla Rivers MPG						
Willow Creek	Extinct	Summer	Intermediate	B-Dendritic	1,000	1.35
Umatilla River	Extant	Summer	Large	B-Dendritic	1,500	1.26
Walla Walla River	Extant	Summer	Intermediate	B-Dendritic	1,000	1.35

[a]Threshold abundance is the minimum abundance criteria to achieve a 5% or less risk of extinction at the minimum productivity.

[b] Large size category is for historically accessible area; intermediate size category is for currently accessible area.

The ICTRT also developed specific guidance for assessing current status relative to the Abundance/Productivity viability risk curves (ICTRT 2006). Using this guidance, mean abundance and standard error were calculated as the most recent 10-year geometric mean of natural-origin spawners. Productivity was calculated as recruits per spawner (spawner to spawner) from the 20 most recent completed brood years (less if only that was available). Only natural-origin fish were counted as recruits, and both natural-origin and hatchery-origin fish spawning naturally were counted as parents. No relative reproductive success factors were applied to hatchery parents. The team determined low abundance/productivity by limiting the data series to only include the low abundance parent population sizes. This delimiting was conducted to address the influence of density on recruits-per-spawner. It determined the median parent abundance level, and used the values equal to or less than the median in most cases. In those cases where the median was not used, it censused at 75% of the threshold. In most cases, this resulted in ten recruits-per-spawner data points. To further increase the accuracy and precision of the productivity estimate, the recruits-per-spawner values were adjusted to represent average smolt-to-adult return rates (SAR), thus reducing the variation resulting from variable smolt out-migration and marine survival. The ICTRT calculated a geometric mean and standard error from the censused, SAR adjusted recruits per spawner dataset. It used an aggregate SAR developed from Deschutes, Umatilla, Snake, and Columbia rivers SAR data sets.

The Oregon technical team used the following approach to consider uncertainty in the risk rating. The approach we selected was one of three options presented by the ICTRT (2007). Under this approach, a lower 90% confidence interval bounds was determined to compare against the viability curves. When the lower end of the 90% CI for productivity resides above the 25% risk curve, there is a 95% probability that the true value is above the 25% risk level. To be considered low risk, the point estimate must reside above the 5% risk level for abundance and productivity and the lower 90% CI bound for productivity must reside above the 25% risk level. To be considered very low risk, the point estimate for abundance and productivity must reside above the 1% risk level and there must be less than 1 in 100 chance (the lower end of the 98% CI resides above the 25% risk curve) that the true productivity value is below the 25% risk level. If the point estimate for abundance and productivity falls between the 5% and 25% risk level, then the population is considered at moderate risk regardless of where the 90% CI resides, which equates to a minimum of 50% probability that the true value is above the 25% risk level. Figure 5-1 provides an example of an Abundance/Productivity viability curve.

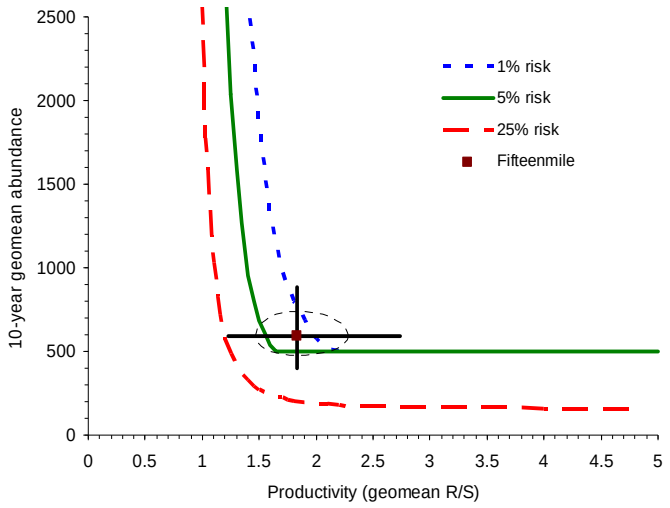


Figure 5-1. Example of Abundance/Productivity viability curves including Fifteenmile Creek current abundance productivity point estimate with standard error elipse and adjusted standard error bounds.

Population Spatial Structure and Diversity

Spatial structure and diversity considerations are combined in the evaluation because they are closely integrated. Spatial structure concerns a population's geographic distribution and the processes that affect that distribution. Diversity refers to the distribution of genetic, life history and phenotypic variation within and among populations.

Distribution influences a population's viability because populations with restricted distribution and few spawning areas are at a higher risk of extinction due to catastrophic environmental events than are populations with more widespread and complex spatial structures. A population with a complex spatial structure, including multiple spawning areas, may experience more opportunity for gene flow, developmental substructure, and life history diversity.

Population-level diversity is similarly important for long-term persistence. Populations exhibiting greater diversity are generally more resilient to short-term and long-term environmental changes. Phenotypic and life history diversity allow populations to use a wider array of environments and protect populations against short-term temporal and spatial environmental changes. Underlying diversity provides the ability to survive long-term environmental changes.

McElhany et al. (2000) provide a number of guidelines for the spatial structure and diversity of viable salmonid populations that consider these principles (Figure 5-2).

Spatial Structure

1. Habitat patches should not be destroyed faster than they are naturally created.
2. Natural rates of straying among subpopulations should not be substantially increased or decreased by human actions.
3. Some habitat patches should be maintained that appear to be suitable or marginally suitable, but currently contain no fish.
4. Source subpopulations should be maintained.
5. Analyses of population spatial processes should take uncertainty into account.

Diversity

1. Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics.
2. Natural processes of dispersal should be maintained. Human-caused factors should not substantially alter the rate of gene flow among populations.
3. Natural processes that cause ecological variation should be maintained.
4. Population status evaluations should take uncertainty about requisite levels of diversity into account.

Figure 5-2. Viable salmonid population spatial structure and diversity guidelines (McElhany et al. 2000).

The ICTRT identified two primary goals that spatial structure and diversity criteria should address:

1. maintain natural rates and levels of spatially mediated processes, and
2. maintain natural patterns of variation.

The ICTRT also provided a format outlining guidelines for achieving these goals. The format identifies mechanisms, factors and metrics appropriate for assessing population status. Mechanisms are biological or ecological processes that contribute to achieving the goals (e.g., gene flow patterns affect the distribution of genotypic and phenotypic variation in a population.) Factors are characteristics of a population or its environment that influence mechanisms (e.g., gaps in spawning distribution affect patterns in gene flow.) Metrics are measured and assessed at regular intervals to determine whether a population has achieved goals or to evaluate its current risk level. Some viability metrics include variable criteria that are dependent on the spatial complexity designation of the population. Table 5-4 summarizes the associations between these goals, mechanisms, factors and metrics. Spatial complexity designations are also presented in Table 5-4.

Table 5-4. Organization of goals, mechanisms, factors and metrics for spatial structure and diversity risk rating (ICTRT 2007).

Goal	Mechanism	Factor	Metrics
A. Allowing natural rates and levels of spatially-mediated processes.	1. Maintain natural distribution of spawning areas.	a. Number and spatial arrangement of spawning areas.	Number of MaSAs, distribution of MaSAs, and quantity of habitat outside MaSAs.
		b. Spatial extent or range of population.	Proportion of historical range occupied and presence/absence of spawners in MaSAs.
		c. Increase or decrease gaps or continuities between spawning areas.	Change in occupancy of MaSAs that affects connectivity within the population.
B. Maintaining natural levels of variation.	1. Maintain natural patterns of phenotypic and genotypic expression.	a. Major life history strategies.	Distribution of major life history expression within a population.
		b. Phenotypic variation.	Reduction in variability of traits, shift in mean value of trait, loss of traits.
		c. Genetic variation.	Analysis addressing within and between population genetic variation.
	2. Maintain natural patterns of gene flow.	a. Spawner composition.	(1) Proportion of natural spawners that are unnatural out-of ESU spawners.
			(2) Proportion of natural spawners that are unnatural out-of MPG spawners.
			(3) Proportion of hatchery origin natural spawners derived from a within MPG brood stock program, or within population (not best practices) program.
			(4) Proportion of hatchery origin natural spawners derived from a local (within population) broodstock program using best management practices.
	3. Maintain occupancy in a natural variety of available habitat types.	a. Distribution of population across habitat types.	Change in occupancy across ecoregion types.
	4. Maintain integrity of natural systems.	a. Selective change in natural processes or impacts.	Ongoing anthropogenic activities inducing selective mortality or habitat change within- or out-of-population boundary.

Integrating the Four VSP Parameters

These abundance/productivity and spatial structure/diversity considerations form the centerpiece of the ICTRT's framework for assessing ESU viability (ICTRT 2007). The approach is based on guidelines in McElhany et al. (2000), the results of previous applications (i.e., Puget Sound and Lower Columbia/Willamette TRTs and Upper Columbia Qualitative Analysis Review), and a review of specific information available relative to listed Interior Columbia ESU populations.

The ICTRT integrates all four VSP parameters using a simple matrix approach (Figure 5-3). The abundance/productivity (A/P) risk level combines the abundance and productivity VSP criteria

using a viability curve. The spatial structure/diversity (SS/D) risk level integrates across 12 measures of spatial structure and diversity. The overall diversity viability rating for any population is determined using two guiding principles. First, the VSP concept (McElhany et al. 2000) provides a 5% risk criterion to define a viable population. Therefore, any population scored moderate or high risk in the abundance/productivity criteria would not meet the recommended viable standards. In addition, any population that is high risk in SS/D would not be considered viable. Second, populations with a very low rating for A/P and at least a low rating for SS/D are considered to be "Highly Viable." Populations with a low rating for A/P and a very low, low, or moderate rating for SS/D are considered "Viable." In addition, populations with a very low risk rating for A/P and a moderate rating for SS/D are also considered "Viable." This integration approach places greater emphasis on the abundance/productivity criteria. These individual ratings are then integrated to determine the viability of major population groups. The assessments of individual MPGs are aggregated to assess the DPS as a whole (ICTRT 2007).

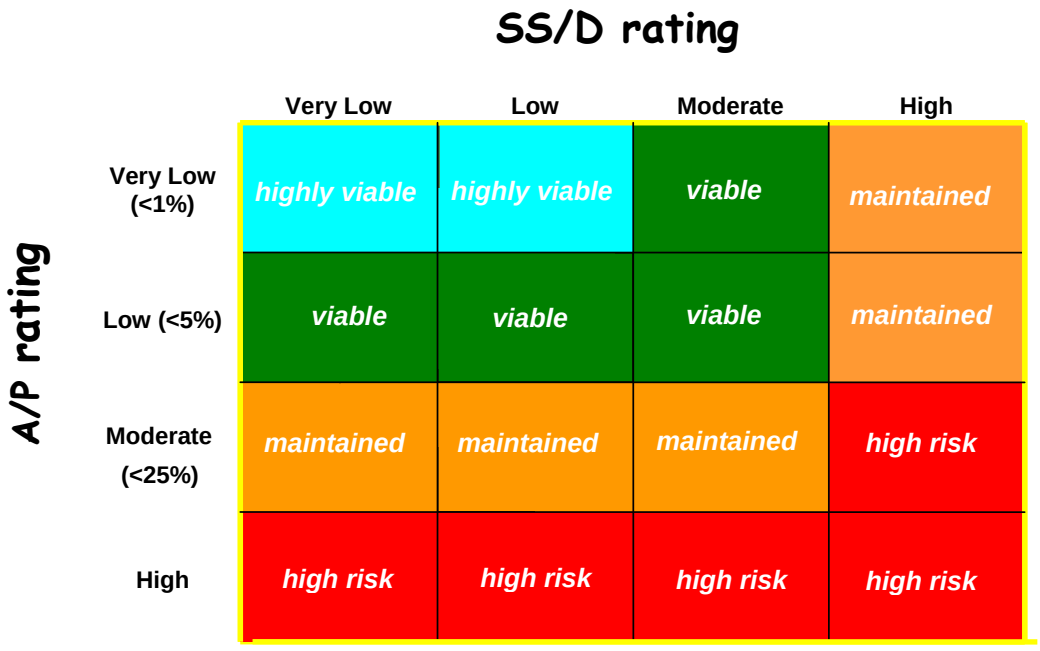


Figure 5-3. Assessing population viability across VSP criteria (ICTRT 2007).

Percentages for abundance and productivity scores represent the probability of extinction in a 100-year time period. The ICTRT used the analysis approach discussed in this section to examine the viability of independent populations in the Mid-Columbia River steelhead DPS.

5.1.3 Major Population Group Viability Criteria

The ICTRT recommended MPG-level risk criteria that assess the level of risk associated with its component populations. While individual populations meeting viability criteria are expected to have low risk of extinction, these additional MPG-level criteria ensure robust functioning of the population group and provide resilience to catastrophic loss of one or more populations. In developing these criteria, the ICTRT assumed that catastrophes do not increase dramatically in frequency, that populations are not lost permanently (due to catastrophe or anthropogenic

impacts) and that permanent reductions in productivity, including long-term, gradual reductions in productivity do not occur (ICTRT 2007). Figure 5-4 shows MPG-level viability criteria identified by the ICTRT.

MPG Viability Criteria (ICTRT 2007)

The following six criteria must be met for an MPG to be regarded as low risk (viable):

1. One-half of the populations historically within the MPG (with a minimum of two populations) must meet at least minimum viability standards.
2. At least one population must be categorized as being "Highly Viable".
3. Viable populations within an MPG must include some populations classified (based on historical intrinsic potential) as "Very Large," or "Large," and "Intermediate" in the same proportion as were present within the MPG historically.
4. Populations not meeting viability standards should be maintained with sufficient productivity that the overall MPG productivity does not fall below replacement (i.e., these areas should not serve as significant population sinks).
5. Where possible, given other MPG viability requirements, some populations meeting viability standards should be contiguous AND some populations meeting viability standards should be disjunct from each other.
6. All major life history strategies (e.g. spring and summer run timing) that were present historically within the MPG must be represented in populations meeting at least the minimum viability requirements.

Figure 5-4. MPG-level viability criteria identified by the ICTRT (ICTRT 2007).

MPG Recovery Scenarios Options

We identified the following options for the three MPGs containing Oregon Mid-C steelhead populations. The Cascades Eastern Slope Tributaries and the Umatilla/Walla Walla MPGs contain populations that reside in Oregon and Washington. Although this recovery plan deals specifically with Oregon populations, we present MPG recovery scenarios considering all populations within each MPG.

Cascades Eastern Slope Tributaries Major Population Group

This MPG contains seven populations, including four Oregon populations, shown in Table 5-5.

Table 5-5. Characteristics of steelhead populations in Cascades Eastern Slope Tributaries MPG.

Population	Extant/Extinct	Life History	Size Category
Fifteenmile Creek	Extant	Winter Run	Basic
Deschutes River Eastside	Extant	Summer Run	Intermediate
Deschutes River Westside	Extant	Summer Run	Large
Deschutes Crooked River	Extinct	Summer Run	Very Large
Klickitat River	Extant	Winter/Summer Run	Intermediate
White Salmon	Extinct	Summer Run	Intermediate
Rock Creek	Extant	Summer Run	Basic

The following ICTRT criteria are recommended for this MPG to be regarded as viable:

1. Four of the seven historical populations in the MPG meet viable criteria standards.
2. One very large/large and two intermediate size populations must be included for the MPG to have proportional representation of the Very Large/Large and Intermediate sizes. The fourth population can be any size from basic to very large.
3. At least one summer run, one winter run, and one population with winter/summer combination must be included for all of the historical major life history strategies to be represented.
4. One of the four viable populations must be highly viable.
5. All populations that do not meet viable status have to meet maintained status.

Given the above criteria, the only viability scenario for this MPG must include the following populations:

- Fifteenmile Creek—represents a winter run requirement and small size.
- Deschutes River Eastside—represents a summer run and intermediate size requirement.
- Deschutes River Westside—represents a summer run and large size requirement.
- Klickitat River—represents a winter/summer run and an intermediate size requirement.
- Rock Creek—must be maintained.

John Day River Major Population Group

This MPG contains five populations. Their characteristics are described in Table 5-6.

Table 5-6. Characteristics of steelhead populations in the John Day River MPG.

Population	Extant/Extinct	Life History	Size Category
Lower Mainstem John Day	Extant	Summer Run	Very Large
North Fork John Day	Extant	Summer Run	Large
Middle Fork John Day	Extant	Summer Run	Intermediate
South Fork John Day	Extant	Summer Run	Basic
Upper Mainstem John Day	Extant	Summer Run	Intermediate

The following ICTRT criteria are recommended for this MPG to be regarded as viable:

1. Three of the five historical populations in the MPG must meet viable criteria standards.
2. Viable populations within the MPG must include two very large/large and one intermediate size population to have proportional representation of the population sizes.
3. All major life history strategies present historically must be represented. There are only summer-run life histories.
4. One of the three viable populations must be highly viable.

5. All populations that do not meet viable status must be maintained.

Given the above criteria, a viability scenario for this MPG must include the following populations:

- Lower Mainstem John Day—represents the only population that meets the very large size requirement.
- North Fork John Day—represents a highly viable population and a large size requirement.
- Middle Fork John Day or Upper Mainstem John Day—either population could meet the second intermediate size requirement.
- South Fork John Day—must be maintained.

Umatilla/Walla Walla Rivers Major Population Group

This MPG contains four populations, including three Oregon populations, shown in Table 5-7.

Table 5-7. Characteristics of steelhead populations in Umatilla/Walla Walla Rivers MPG.

Population	Extant/Extinct	Life History	Size Category
Willow Creek	Extinct	Summer Run	Intermediate
Umatilla River	Extant	Summer Run	Large
Walla Walla River	Extant	Summer Run	Intermediate
Touchet River	Extant	Summer Run	Intermediate

The following ICTRT criteria are recommended for this MPG to be regarded as viable:

1. Two of the four historical populations in the MPG must meet viable criteria standards.
2. Viable populations within the MPG must include one large and one intermediate size populations.
3. All major life history strategies present historically must be represented. There are only summer-run life histories.
4. One of the two viable populations must be highly viable.
5. All populations that do not meet viable status must be maintained.

Given the above criteria, the following two viability scenarios are options:

- Umatilla River—this population is required to meet the large size requirement because it is the only large size population.
- Walla Walla River or Touchet River—either population could meet the second population requirement at intermediate size.

5.1.4 DPS Viability Criteria

The ICTRT determined that, because MPGs are geographically and genetically cohesive groups of populations, they are critical components of ESU/DPS-level spatial structure and diversity. Having all MPGs within the DPS at low risk provides the greatest probability of persistence for the DPS. Figure 5-5 shows DPS-level viability criteria defined by the ICTRT.

DPS-Level Viability Criteria (from Cooney et al. 2005)

1. All extant MPGs and any extirpated MPGs critical for proper functioning of the DPS must be at low risk.

2. DPSs that contained only one MPG historically or that include only one MPG critical for proper function must meet the following criteria:
    a. The single MPG must meet all the requirements to be at low risk (see above). In addition:
    b. Two-thirds or more of the populations within the MPG historically must meet minimum viability standards; AND
    c. At least two populations must meet the criteria to be "Highly Viable."

These extirpated areas will be evaluated to determine whether extirpated MPGs are critical for proper functioning of the DPS using the following considerations:

- Likely demographic (abundance and productivity) contribution of the MPG and its component populations to the DPS.
- Spatial role of the MPG in the DPS (e.g. does the extirpated MPG create a gap in the distribution of the DPS?)
- Likely contribution to overall DPS diversity (e.g. does the extirpated MPG occupy habitats that are substantially different from other habitats currently occupied in the DPS?)

Figure 5-5. DPS-level viability criteria identified by the ICTRT (ICTRT 2007).

5.2 Broad Sense Recovery Goal and Objectives

After achieving steelhead recovery under the ESA, the State of Oregon aims to rebuild Oregon's Mid-C steelhead populations to levels that will provide for sustainable fisheries and other ecological, cultural and social benefits. Although broader than the definition of delisting provided by the ESA, these broad sense goals incorporate many of the traditional uses, as well as rural and Native American values, deemed important in the Pacific Northwest.

During the recovery planning effort, the Oregon Middle Columbia Steelhead Sounding Board led the development of broad sense recovery goals for the region. The Sounding Board included citizens from all Oregon subbasins within the Mid-Columbia steelhead DPS. During the process, the board members worked with recovery planners to identify goals and objectives that would provide abundance, productivity, and diversity well above delisting levels to allow for sustainable fisheries and other cultural uses. The Sounding Board (2006) identified the following broad sense recovery goal and objectives.

Broad Sense Recovery Goal

Oregon's broad sense recovery goal for the Mid-C Steelhead is founded on a belief that citizens throughout the region value and enjoy the substantial ecological, cultural, social, and economic benefits that are derived from having healthy, diverse populations of steelhead.

Oregon's Mid-Columbia River natural steelhead populations are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) so that they provide significant ecological, social, cultural, and economic benefits.

To achieve these benefits for current and future generations, this recovery plan aims to restore Mid-C steelhead in Oregon subbasins to the point where their protection under the ESA is no longer needed and a range of societal benefits are met. Recovery of Mid-Columbia steelhead populations will require actions that preserve, enhance and restore healthy watershed conditions where ecosystem functions, processes and dynamics are intact ─ including instream conditions, riparian habitat diversity and complexity, and upland watershed health in concert with complementary management of harvest, hatcheries and hydropower. Recovery is a process that leads to steelhead populations that are not only viable, but that also provide a harvestable surplus for the treaty tribes and for all other citizens of the region.

This vision for broad-sense recovery incorporates ESA delisting goals in the sense that delisting would be achieved *first* during an extended and stepwise process of achieving broad sense recovery goals. ESA delisting criteria are entirely science-based and establish the biologically-based standards required to sustain the DPS. In contrast, broad-sense recovery represents a level of population performance that will considerably exceed the delisting level.

Recovery Objectives
By the year 2050, proponents of the Middle Columbia River Steelhead Recovery Plan intend to achieve the following objectives:

1. Middle Columbia steelhead are viable throughout the historical range and no longer need protection under the ESA;

2. All currently extant Middle Columbia steelhead populations are highly viable;

3. Extirpated populations (e.g. Willow Creek, Crooked River) are restored in a manner that engages landowner cooperation and does not subject landowners to ESA regulation based on the presence of previously extirpated populations until the introduced populations are self-sustaining and become part of the listed DPS;

4. All extant populations of Middle Columbia steelhead are capable of contributing ecological, social, cultural, and economic benefits on a regular and sustainable basis;

5. Working in concert with existing agreements and collaboratively with landowners and resource managers NOAA will define a suite of additional land and water resource management principles and practices that when followed will alleviate liability for possible ESA regulatory consequences to landowners and resource managers;

6. Out-of-basin limiting factors are addressed equitably and in concert with in-basin limiting factors;

7. Landowners, land managers and agencies are provided with guidance on the protection and management of habitats to promote the recovery of Mid-C steelhead; and,

8. Land and resource managers work with communities and other interests in a coordinated manner to achieve broad sense recovery through a shared vision of conservation where options and choices are preserved for future generations.

A number of actions are needed to accomplish the goal and objectives:

1. Collaborative management processes and approaches, including both volunteer and incentive-based programs, encourage restoration of habitat.

2. Management actions are based on a strategic priority framework that recognizes the importance of protection, enhancement, and restoration throughout the life cycle of the species.

3. Agencies and residents employ a diversity of management approaches across the DPS that meet both social and biological objectives.

4. Landowners and resource managers are provided with information and assistance on how to accomplish recovery goals and objectives.

5. A coordinated research, monitoring, and evaluation program is in place that will facilitate periodic assessments of implementation effectiveness, population status, habitat status, and advise the need, if any, to modify future recovery management actions within an adaptive management framework.

Section 6 Current Status — Viability Assessments

This section summarizes the current status of Oregon's ten independent populations of Mid-C steelhead based on viability assessment results. It also describes the role of each population in achieving viable status at the MPG level. Detailed individual population viability assessments are presented in Appendix B. Section 5 describes the ICTRT's approach and criteria for assessing population viability. All error bars shown represent 90% confidence intervals (CI) unless otherwise indicated. In those cases where 98% CIs are shown is for the purpose of determining if uncertainty criteria for highly viable status has been met.

6.1 Fifteenmile Creek Winter Steelhead Population

The Fifteenmile Creek population occupies the Fifteenmile watershed and several smaller drainages — Rock, Mosier, Chenoweth, Mill, and Threemile — outside the Fifteenmile watershed. The population contains three MaSAs, located in the Fifteenmile Creek watershed: Upper Fifteenmile, Eightmile, and Fivemile. It also occupies five MiSAs: lower Fifteenmile, Threemile, Mill, Chenoweth, and Mosier.

The Fifteenmile Creek Winter Steelhead population is at low risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 703. During the period 1985-1999, returns per spawner in the Fifteenmile Creek population ranged from 0.37 (1987) to 5.58 (1998). The most recent 15-year (1985-1999) SAR adjusted and delimited geomean of returns per spawner was 1.82 (Appendix B).

Figure 6-1 shows the viability curve for the Fifteenmile Creek population. The Abundance/Productivity (A/P) point estimate resides above the 1% risk curve, but the population is not considered to be at very low risk because of uncertainty criteria, the 98% confidence interval (CI) extends below the 25% risk curve. However, since the 90% CI is above the 25% risk curve, the population is rated at low risk. These A/P results should be viewed with caution, as abundance and productivity estimates for the population are based on 15 years of spawner/recruit data.

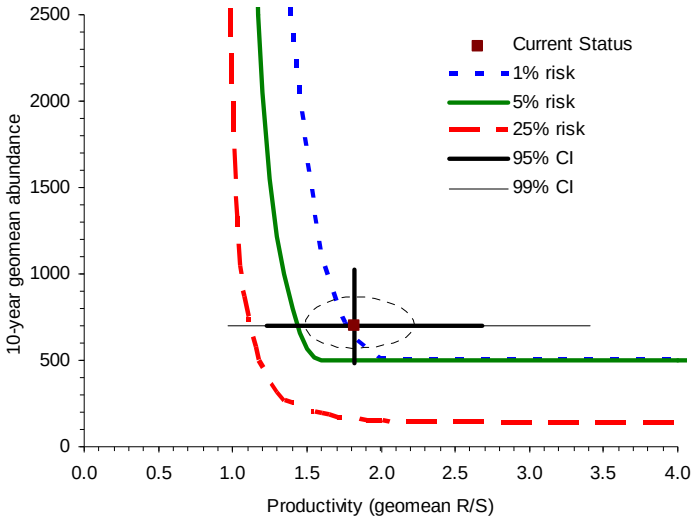


Figure 6-1. Fifteenmile Creek Winter Steelhead population abundance and productivity compared to the DPS viability curve.

The integrated Spatial Structure/Diversity (SS/D) rating is low risk for the Fifteenmile population. There has been little change in distribution relative to the historical distribution. The absence of major reductions in distribution resulted in a rating of very low risk for the spatial structure metrics. We hypothesize that there have been minor reductions in life history diversity and phenotypic variation, but these changes are not severe enough to raise risk levels to moderate. There are few hatchery fish in the population resulting in low risk for spawner composition.

Overall Risk Rating

The Fifteenmile Creek population currently meets criteria for viable status because both Abundance/Productivity and Spatial Structure/Diversity are rated at low risk. The productivity value of 1.82 is above the minimum 1.65 required at the threshold abundance, and the 10-year geomean of natural-origin spawners is well above the viable threshold of 500 for a "basic" size population. A relatively small increase in productivity and reduction in the CI are required to move this population into "highly viable" status. Additional data points will likely decrease the standard error and move the 98% confidence interval out of the high risk region. Monitoring should be continued to allow analysis of a longer data time series.

6.2 Deschutes River Eastside Summer Steelhead Population

The Deschutes River Eastside population includes the mainstem Deschutes River from the mouth to above the Pelton-Round Butte Complex at RM 100, and tributaries joining the Deschutes from the Eastside. Areas above the complex, including Willow Creek, are currently inaccessible. The population contains six MaSAs: Buck Hollow, Bakeoven, Ward/Antelope/Cold/Carp, Lower Trout, Upper Trout and Willow. It contains two MiSAs: Jones Canyon and Campbell. The Willow Creek MaSA and Campbell MiSA are in the inaccessible area above the complex.

The Deschutes River Eastside Summer Steelhead population is at low risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 1,599. During the period 1990-1999, returns per spawner for steelhead in the Deschutes River Eastside ranged from 0.24 (1991) to 3.97 (1996). The most recent 10-year (1990-1999) geomean of returns per spawner SAR adjusted and median delimited was 1.89 (Appendix B).

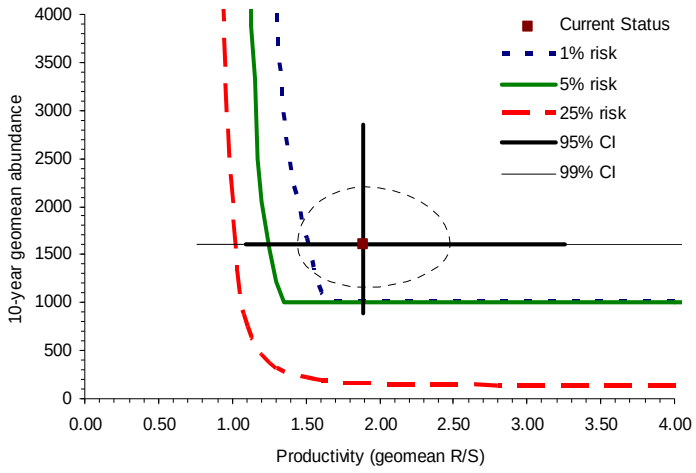


Figure 6-2. Deschutes River Eastside Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The current point estimate for productivity on the viability curve for the Deschutes River Eastside Summer Steelhead population resides above the 1% curve, but the population is not considered to be at very low risk since the 98% CI extends below the 25% risk curve (Figure 6-2). Since the 90% CI is above the 25% risk curve, the population is rated at low risk.

The integrated Spatial Structure/Diversity rating is moderate risk for the Deschutes Eastside population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was low risk. Although the overall rating for this goal was low, spawning distribution is reduced significantly from the historical distribution with loss of spawning in the Willow Creek drainage being the primary factor. The population remains broadly distributed with little change in gaps and good continuity within the currently accessible habitat.

The rating for Goal B "maintaining natural levels of variation" was moderate risk. Habitat changes in key tributary production areas have likely resulted in limitations to life history diversity and reduction in phenotypic expression. In addition, a significant proportion of natural spawners are out-of-DPS strays that resulted in a high risk rating for the spawner composition metric. Additional genetics information is needed to assess within and between population differentiations, and to improve our understanding of the degree of introgression of out-of-DPS strays. The ongoing genetics work of the USFWS and co-managers will provide the information needed to better assess the genetic health of this population.

Overall Risk Rating
The Deschutes River Eastside population currently meets the ICTRT recommendation for viable status. The 10-year geomean of natural fish abundance of 1,599 is well above the threshold of 1,000. The point estimate of productivity (1.89) puts the population into the very low risk region; however the 90% CI extends well below the 25% risk level. This wide standard error results in a low risk level for abundance/productivity. The spatial structure/diversity rating is moderate risk, primarily because of the influence of habitat changes on life history and phenotypic expression as well as out-of-DPS hatchery spawners.

6.3 Deschutes River Westside Summer Steelhead Population

The Deschutes River Westside population includes the mainstem Deschutes River from Trout Creek to the Pelton-Round Butte Complex at RM 100, and tributaries joining the Deschutes from the Westside. Current distribution is reduced significantly from the historical distribution because of loss of accessibility to the Metolius River and Whychus Creek drainages. Spawning is currently concentrated in the Warm Springs River and Shitike Creek, and in the mainstem Deschutes River between Trout Creek and Pelton Dam. The population contains six MaSAs (Upper Warm Springs, Mill, Beaver, Shitike, Upper Metolius and Whychus) and nine MiSAs (Lower Warm Springs, Oak Canyon, Seekseekqua, Wapinitia, Lower Warm Springs Tribs, Trahan, Eagle, Skookum, and Dry) in the historically accessible habitat.

The Deschutes River Westside Summer Steelhead population is at high risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 456, which is below the minimum abundance threshold of 1,000 spawners for an "intermediate" size population. During

the period 1980-1999, returns per spawner for steelhead in the Deschutes River Westside population ranged from 0.24 (1987) to 3.72 (1996). The most recent 20-year (1979-1998) geomean of returns per spawner SAR adjusted and delimited at 75% of threshold was 1.05 (Appendix B).

The current point estimate for Abundance/Productivity on the viability curve for the Deschutes River Westside Summer Steelhead population resides below the 25% risk curve (Figure 6-3).

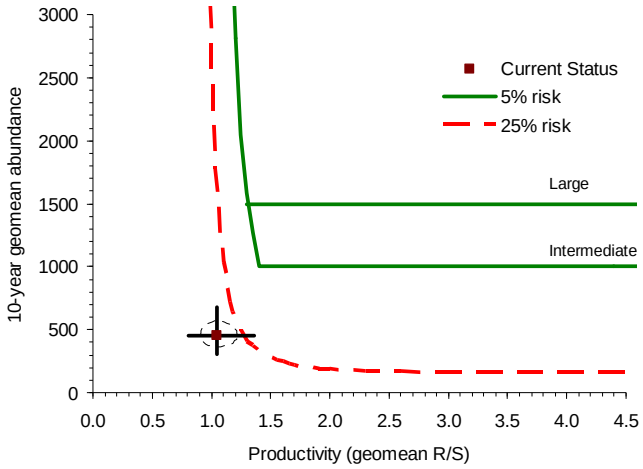


Figure 6-3. Deschutes River Westside Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The integrated Spatial Structure/Diversity rating is high risk for the Deschutes River Westside population. The population rates at moderate risk for two of the spatial distribution metrics because the current distribution is substantially reduced from the historical intrinsic distribution due to blocked passages to areas above the Pelton-Round Butte Complex. Ratings for two metrics related to Goal B "maintaining natural patterns of variation" resulted in a moderate rating for Goal B and the overall moderate rating. Genetic variation rated moderate due to limited data and the lack of differentiation between the Deschutes samples and outside-basin hatchery samples. Samples collected in 2005-2006 will better inform the risk associated with genetic variation. The proportion of out-of-DPS hatchery strays resulted in a high risk rating for spawner composition. Most of these strays originate from the Snake River Basin.

Overall Risk Rating

The Deschutes River Westside steelhead population does not currently meet the ICTRT recommended viability criteria and is currently high risk status because the Abundance/Productivity is rated at high risk, and the Spatial Structure/Diversity rating is moderate risk. The 10-year geometric mean abundance of 456 is well below the minimum threshold of 1,000 required for an intermediate size population. The abundance of 456 is slightly below the minimum 500 recommended by the ICTRT for maintained status. A substantial increase in productivity will be required to raise the abundance/productivity values to the low risk level. The genetics information that is presently being collected will better inform the genetics variation risk level in the future. A reduction in the out-of-ESU hatchery stray proportion will be needed to reduce the risk rating for the spawner composition metric.

6.4 Lower Mainstem John Day River Summer Steelhead Population

The Lower Mainstem John Day River population occupies the Lower John Day watershed below the town of Dayville at the mouth of the South Fork John Day River. Steelhead in the Lower Mainstem John Day River population spawn in tributary streams connected by the lower John Day River, including Bridge, Butte, Thirtymile, Service, Mountain and Rock creeks. Multiple smaller drainages also support production. The population contains 11 MaSAs and 19 MiSAs. MaSAs include: Bridge, Mountain, Cottonwood, Middle Rock, Upper Rock, Pine Hollow, Lone Rock, Thirtymile, Butte, Hay, and Grass Valley. MiSAs include: Esau Canyon, Kahler, Jackknife, Pine (John Day), Service, Ferry, Rhodes Canyon, Rowe, Currant, Johnson (John Day), Shoofly, Girds, Cherry, Bologna, Buckhorn, Cottonwood Canyon, Lower Rock 1, Lower Rock 2, and Haystack.

The Lower Mainstem John Day River Summer Steelhead population is at moderate risk based on current abundance and productivity. Spawner abundance in recent years has been highly variable; the most recent 10-year geomean number of natural-origin spawners was 1,800. During the period 1975-1997, returns per spawner for steelhead in the population ranged from 0.14 (1987) to 17.5 (1979). The most recent 19-year (1980-1998) SAR adjusted and delimited geomean of returns per spawner was 2.99 (Appendix B).

The population's productivity is at very low risk. The current point estimate for productivity on the viability curve is above very low risk and the lower end of the adjusted standard error is above the 5% risk level. The abundance is moderate risk because it resides between the 5% and 25% risk levels (Figure 6-4).

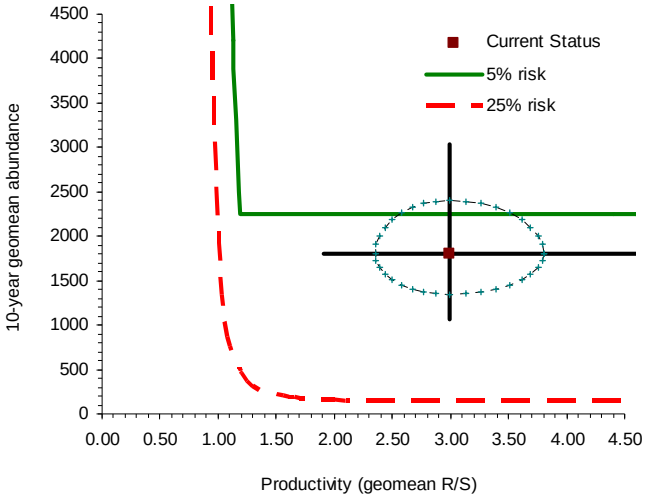


Figure 6-4. Lower Mainstem John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The integrated Spatial Structure/Diversity rating is moderate risk for the Lower Mainstem John Day River population. The rating for Goal A "allowing natural rates and level of spatially mediated processes" was very low. The current spawner distribution is similar to historical with all MaSAs occupied. The MiSAs that are currently unoccupied have little influence on gaps and continuity, and spawners are spread over a very broad geographic area. The rating for Goal B "maintaining natural levels of variation" was moderate risk. This rating was a result of moderate risk for life history and genetic variation, and high risk for spawner composition out-of-DPS hatchery strays. The magnitude and trend in out-of-DPS hatchery strays are of significant

concern. Analysis of genetics information will yield considerable insight into the population's genetic variation and characteristics. Examining genetics data for evidence of hatchery introgression will be useful for future spatial structure/diversity risk assessments.

Overall Risk Rating

With a moderate rating for Abundance/Productivity and a moderate rating for Spatial Structure/Diversity, the Lower Mainstem John Day River Summer Steelhead population does not currently achieve an overall rating of viable according to ICTRT criteria, although it does meet the criteria for a "maintained" population with abundance well above the 500 minimum recommended by the ICTRT for maintained status. To achieve a viable rating, this population must improve in both Abundance/Productivity and Spatial Structure/Diversity. Out-of-DPS origin spawners are the most influential factor on Diversity Risk. Additional population specific data are needed to better quantify the spawner composition in this population to reduce the uncertainty associated with this risk metric.

6.5 North Fork John Day River Summer Steelhead Population

The North Fork John Day is the largest tributary to the John Day River. The North Fork John Day River population contains eight MaSAs: Lower North Fork John Day, Potamus, Big Wall, Big, Upper North Fork John Day, Desolation, Granite and Owens. It contains seven MiSAs: Meadow Brook, Fivemile (North Fork), Ditch, Cabin, Meadow (North Fork), Cabin (North Fork) and Bridge (North Fork). Spawning is distributed broadly throughout the population boundaries including mainstem areas of Cottonwood, Camas, Desolation, and Granite creeks, and the Upper North Fork John Day River, as well as in many tributaries.

The North Fork John Day River Summer Steelhead population is at very low risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 1,740 (1,898 total spawners). During the period 1973-1997, returns per spawner for steelhead in the North Fork John Day River ranged from 0.10 (1985) to 3.07 (1991). The most recent 20-year (1978-1997) SAR adjusted and delimited geomean of returns per spawner was 2.41 (Appendix B).

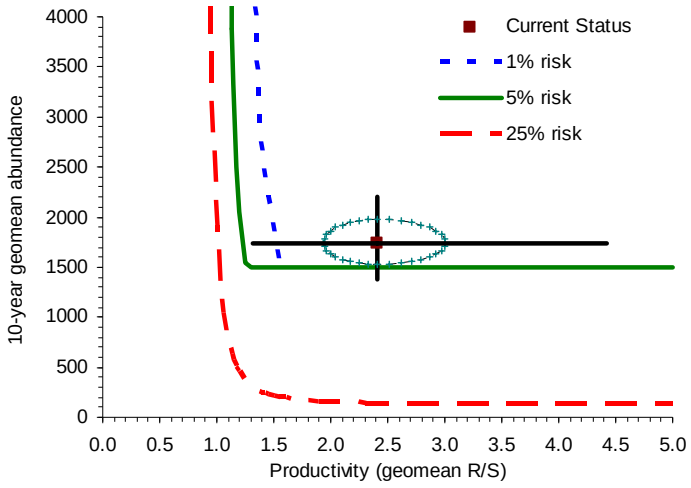


Figure 6-5. North Fork John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The current point estimate for Abundance/Productivity on the viability curve for the population resides above the 1% risk curve and the 98% confidence interval for productivity is above the 25% risk curve (Figure 6-5). The productivity value of 2.41 is well above the minimum needed at threshold abundance, and the abundance of 1,740 is above the 1,500 threshold for a "large" size population.

The combined integrated Spatial Structure/Diversity rating is low risk for the North Fork John Day population. The rating for Goal A "allowing natural rates and level of spatially mediated processes" was very low. The current spawner distribution mimics the intrinsic distribution. The population is distributed broadly across the landscape in numerous MaSAs and MiSAs. Good continuity exists between spawning areas and current gaps between spawning areas are similar to historical gaps. The rating for Goal B "maintaining natural levels of variation" was low risk. However, there remains considerable uncertainty about the ratings for genetic variation and out-of-DPS hatchery strays in the natural spawners. Additional genetic analyses and interpretation is needed to determine if the genetic variation is similar to historical conditions and to examine evidence for degree of stray hatchery fish introgression. We rated the metric for out-of-DPS hatchery strays as very high. The data used for this rating are a composite from four John Day populations. Additional population specific spawner composition data are needed to improve the certainty of the out-of-DPS stray hatchery risk rating. If there is significant hatchery introgression that is affecting the genetic variation through time, the risk rating for "genetic variation" will increase and the overall risk rating for Goal B and Spatial Structure/Diversity will also increase.

Overall Risk Rating
The overall viability rating for the North Fork John Day River Summer Steelhead population is highly viable as a result of the Abundance/Productivity rating of very low risk, and the Spatial Structure/Diversity rating of low risk. The productivity value of 2.41 is well above the minimum needed at threshold abundance, and the abundance of 1,740 is above the minimum of 1,500 natural-origin spawners for a large size population. The Spatial Structure/Diversity metric ratings for genetic variation and out-of-DPS hatchery-origin spawner composition were the most influential on the overall Spatial Structure/Diversity assessment. There is considerable uncertainty regarding the genetic effect of out-of-DPS strays as well as the actual proportion of natural spawners that are hatchery strays. Enhanced monitoring efforts should be undertaken to develop better estimates of the composition of North Fork John Day spawners.

6.6 Middle Fork John Day River Summer Steelhead Population

The Middle Fork John Day population contains two MaSAs, Middle Fork John Day and Long Creek; it does not contain any MiSAs. Spawning is distributed broadly throughout the population boundaries, including mainstem areas in the lower and upper Middle Fork John Day and Long Creek. There are numerous tributary spawning streams distributed from the lower end of the population boundary to the uppermost reaches.

The Middle Fork John Day River Summer Steelhead population is at moderate risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 756. During

the period 1969-1998, returns per spawner for steelhead in the Middle Fork John Day River ranged from 0.17 (1992) to 3.84 (1997). The most recent 20-year (1979-1998) geomean of returns per spawner SAR adjusted and delimited was 2.45 (Appendix B).

The current point estimate for Abundance/Productivity on the viability curve for the Middle Fork John Day River summer steelhead population is between 5% and 25% risk curves. This productivity is well above the minimum required at threshold abundance; however, abundance is below the threshold (Figure 6-6).

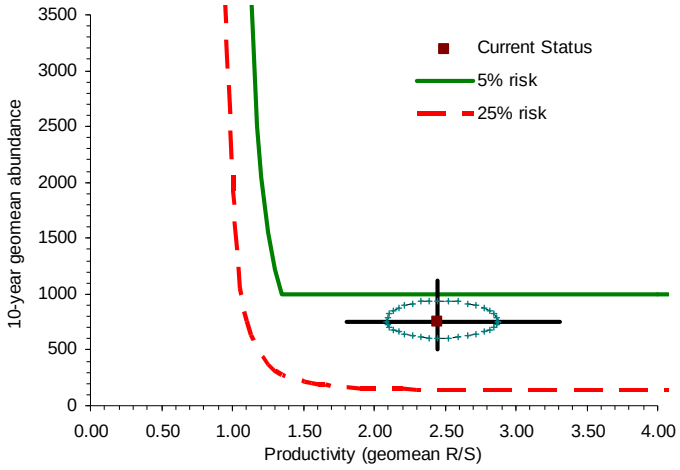


Figure 6-6. Middle Fork John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The integrated Spatial Structure/Diversity rating is low risk for the Middle Fork population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was between very low and low risk. The current spawner distribution of the Middle Fork population mimics the intrinsic distribution. The population is distributed broadly across the landscape, in both MaSAs with adequate gaps and good continuity between spawning areas. The rating for Goal B "maintaining natural levels of variation" was low risk. However, additional genetics analyses are needed to better assess genetic variation and hatchery introgression. This population was rated high risk for proportion of out-of-DPS hatchery strays based on a limited time series of composite John Day population data. Better population specific spawner composition data are needed to better understand the out-of-DPS hatchery stray influence. If there is significant hatchery introgression that affects genetic variation through time, then the risk rating will increase, thus raising the overall risk rating for Goal B and the overall rating for Spatial Structure/Diversity.

Overall Risk Rating

The Middle Fork John Day River Summer Steelhead population does not currently meet the ICTRT criteria for viable status, although it does meet the criteria for a "maintained" population because the abundance is well above the minimum of 500 natural-origin spawners for maintained status. The productivity point estimate of 2.45, as well as the lower end of the adjusted standard error, met the low risk criteria. The abundance of 756 is only 75.6% of the minimum threshold criteria of 1,000 natural-origin spawners for an intermediate size population. Increased annual abundance would allow this population to achieve a risk rating of low for abundance/productivity and raise the overall viability rating to viable.

6.7 South Fork John Day River Summer Steelhead Population

Steelhead spawn, rear, and migrate through the lower South Fork John Day River up to Izee Falls, a natural barrier at RM 28.5, and into Murderers Creek, Canyon Creek and other tributaries. The population contains three MaSAs (Upper South Fork John Day, Lower South Fork John Day and Murderers Creek) and no MiSAs.

The South Fork John Day River Steelhead population is at moderate risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 259. During the period 1961-1998, returns per spawner for steelhead in the South Fork John Day River ranged from 0.20 (1987) to 13.54 (1968). The most recent 20-year (1979-1998) geomean of returns per spawner, adjusted for marine survival and delimited, was 2.06 (Appendix B).

The current point estimate for Abundance/Productivity on the viability curve for the South Fork John Day River summer steelhead population resides between the 25% and 5% viability curves. The lower bound of the adjusted standard error for both the productivity and abundance extend below the 25% risk level (Figure 6-7).

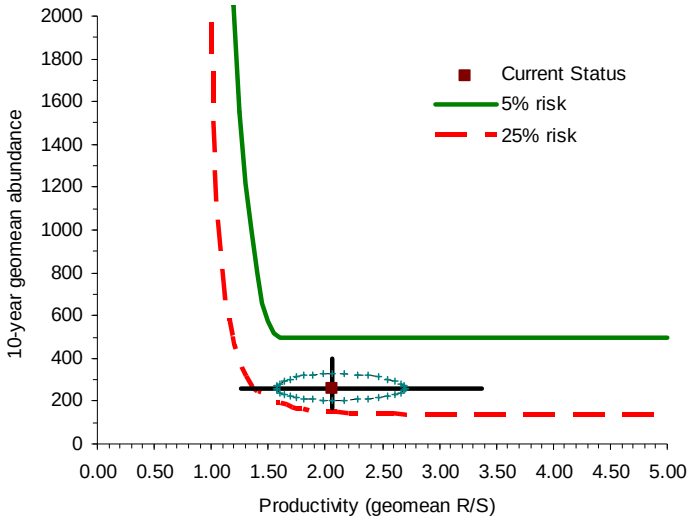


Figure 6-7. South Fork John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The integrated Spatial Structure/Diversity rating is low risk for the South Fork John Day River population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" rated midway between very low and low risk. Although the current spawner distribution mimics the intrinsic distribution, only three MaSAs exist within the population. Good continuity exists between spawning areas and gaps between areas have remained relatively unchanged. The rating for Goal B "maintaining natural levels of variation" is low risk. As is the case for all John Day steelhead populations there is uncertainty in ratings of metrics "genetic variation" and "proportion of spawners that are out-of-DPS strays." We have limited genetics data for South Fork steelhead to determine if the current population variation is similar to historical conditions and to examine the degree of hatchery fish introgression. The metric for proportion of out-of-DPS strays rated as high risk. However, the analyses relied on composite data from four John Day populations. Additional population specific spawner composition data are needed to better inform the risk rating and to reduce the associated uncertainty.

Overall Risk Rating

The South Fork John Day River steelhead population does not currently meet the ICTRT criteria for viable status. The population does meet criteria for a "maintained" population because the abundance exceeds the minimum of 250 natural-origin spawners for maintained status. The recent 10-year geomean abundance of 259 is only 52% of the minimum goal of 500 for viable status of a "basic" size population. The 20-year delimited recruit per spawner point estimate resides above the minimum value required at a 500 abundance level; however, the lower end of the adjusted standard error is below the 25% risk level. Increased productivity in combination with abundance will allow this population to achieve viable status as the Spatial Structure/Diversity criteria achieved a low risk rating. While the population received a Spatial Structure/Diversity rating of low risk, there is considerable uncertainty surrounding the spawner composition data. Enhanced monitoring of the hatchery-wild ratios on the South Fork spawning grounds will improve the hatchery fraction estimate and reduce the degree of uncertainty.

6.8 Upper Mainstem John Day River Summer Steelhead Population

The Upper Mainstem John Day River steelhead population occupies the John Day Basin above the mouth of the South Fork John Day River at Dayville. The population has five MaSAs: Upper John Day, Upper Middle Mainstem John Day, Beech, Laycock, and Canyon. It does not have any MiSAs. Spawning is distributed broadly across the population including mainstem reaches in the Upper John Day River, Canyon Creek, and Beech Creek, as well as in numerous tributaries from Dayville upstream to the headwaters.

The Upper Mainstem John Day River Summer Steelhead population is at moderate risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable, the most recent 10-year geomean number of natural-origin spawners was 524 (572 total spawners). During the period 1969-1998, returns per spawner for steelhead in the Upper Mainstem John Day River ranged from 0.19 (1992) to 5.43 (1979). The most recent 20-year (1979-1998) SAR adjusted and delimited geomean of returns per spawner was 2.14 (Appendix B).

The current point estimate for Abundance/Productivity on the viability curve for the Upper Mainstem John Day River summer steelhead population resides between the 5% and 25% risk curves (Figure 6-8).

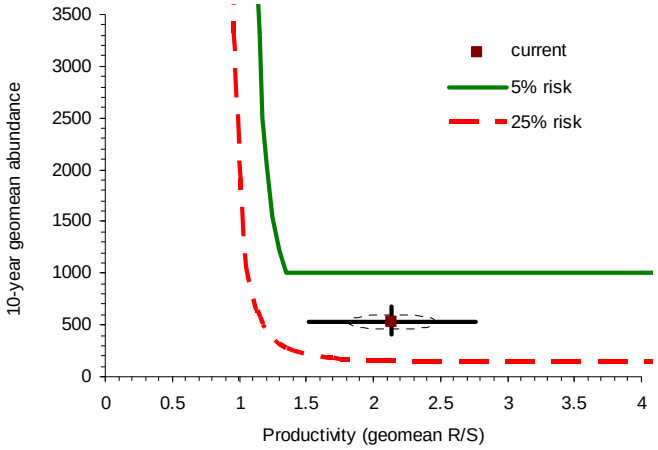


Figure 6-8. Upper Mainstem John Day River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The integrated Spatial Structure/Diversity rating is moderate risk for the Upper Mainstem John Day River population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was very low risk. A rating of "very low" was achieved because the current distribution is nearly identical to the historical distribution. The rating for Goal B "maintaining natural levels of variation" was moderate risk. This risk rating was a result of a moderate rating for changes in major life history strategies. Additional genetics information needs to be assessed to determine current genetic variation and to examine for the degree of introgression of hatchery fish. The population was rated as high risk for out-of-DPS hatchery strays based on a limited time series of composite John Day population hatchery fish observation data. Better population specific spawner composition data are needed to better determine the out-of-DPS hatchery fraction. If there is significant hatchery introgression that affects the genetic variation of this population through time, then the risk rating for Goal B will increase, and the overall risk rating for Spatial Structure/Diversity will increase.

Overall Risk Rating
The Upper Mainstem John Day River Summer Steelhead population does not currently meet the ICTRT criteria for viable status, although it does meet criteria for a "maintained" population. The 10-year geomean abundance of 524 is well below the viable goal of 1,000 natural-origin spawners for an "intermediated" size population; however, the abundance is above the 500 minimum recommended for maintained status of an intermediate size population. The productivity point estimate of 2.14 is above the minimum needed at an abundance of 1,000, and the lower end of the adjusted standard error is above the 25% risk level. An increase in abundance is needed for this population to achieve viable Abundance/Productivity criteria. In addition, the Spatial Structure/Diversity rating was moderate risk due to loss in life history diversity and high risk for spawner composition.

6.9 Umatilla River Summer Steelhead Population

The Umatilla River steelhead population includes thirteen historical MaSAs: Butter, East Birch, West Birch, McKay, Meacham, Middle Umatilla, Lower Middle Umatilla, Upper Umatilla, Lower Umatilla, Lower Birch, Alder, Glade and Wildhorse. It contains three historical MiSAs: Alkali, Fourmile Canyon, and Cottonwood (Umatilla). Two of the MaSAs (Alder Creek and Glade Creek) and one MiSA (Fourmile Canyon) that are included in the Umatilla River population are direct tributaries to the Columbia River on the Washington side of the Columbia. These areas are considered in our assessment of spatial structure/diversity for the Umatilla steelhead population, but are not considered for abundance/productivity because no abundance data are available. Current spawning distribution is somewhat limited relative to historical and is concentrated in Birch Creek, Iskuulpa Creek, Meacham Creek, Upper Umatilla River, and the North and South Forks of the Umatilla River.

The Umatilla River Summer Steelhead population is at moderate risk based on current spawner abundance and productivity. Spawner abundance in recent years has been moderately variable, the most recent 10-year geomean number of natural-origin spawners was 1,472 (2,347 total spawners). During the period 1967-2000, returns per spawner for steelhead in the Umatilla River

ranged from 0.3 (1978) to 4.98 (1998). The most recent 20-year (1981-2000) geomean of returns per spawner SAR adjusted and delimited at 75% of the threshold was 1.50 (Appendix B).

The productivity rating for the Umatilla River summer steelhead population is in the low risk zone because the current point estimate on the viability curve for the population is above 5% risk level and the adjusted standard error is above the 25% risk level. Abundance is moderate because the point estimate is slightly below the 5% risk level (Figure 6-9).

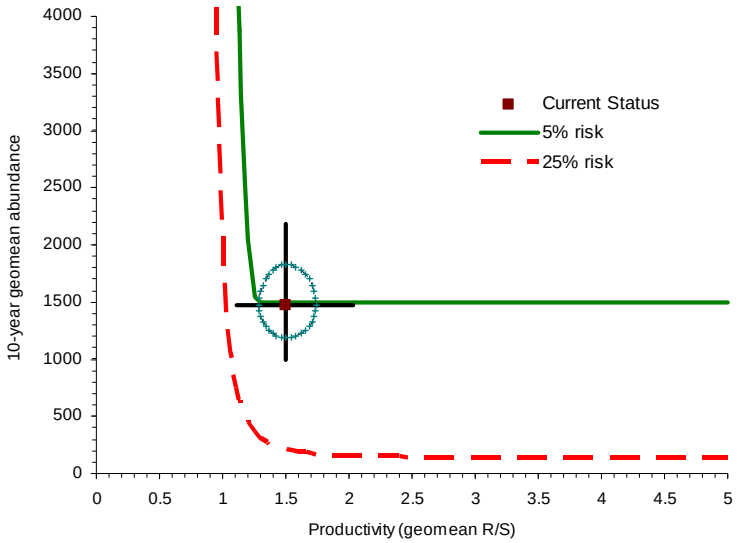


Figure 6-9. Umatilla River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The combined integrated Spatial Structure/Diversity rating is moderate risk for the Umatilla River population. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was moderate risk. There has been significant reduction in spawner distribution relative to intrinsic potential distribution. This reduction has caused significant increases in gaps between spawning areas as well as disrupted continuity. The rating for Goal B "maintaining natural levels of variation" was moderate risk. Habitat changes have been significant in the Umatilla Basin resulting in changes to flow profiles and elevated temperatures. These changes have resulted in impacts to life history diversity and phenotypic trait variation. The out-of-DPS spawners in combination with local-origin hatchery fish spawning naturally put the population at high risk for spawner composition. Hydrosystem effects and within basin habitat changes have likely resulted in selective mortality of specific components of juvenile and adult life stages resulting in a moderate risk rating.

Overall Risk Rating

The Umatilla River Summer Steelhead population does not currently meet the ICTRT criteria for viable status because Abundance/Productivity and Spatial Structure/Diversity risks ratings are both moderate risk. However, the population does meet criteria for a "maintained" population because the abundance level is well above the minimum 500 required for maintained status. The 20-year delimited recruit per spawner point estimate is 1.50 with the lower end of the adjusted standard error above the 25% risk level, thus placing the productivity at low risk. The 10-year mean abundance of 1,472 is 98.1% of the minimum threshold of 1,500. Improvement in many of the Spatial Structure/Diversity metrics and a small increase in the average abundance will raise the population to viable status.

6.10 Walla Walla River Summer Steelhead Population

The Walla Walla Basin spans the Oregon-Washington border east of the Columbia River. The main tributaries of the Walla Walla River are the North and South forks and Couse, Pine, Birch, Cottonwood and Mill creeks. The North and South forks and Couse Creek are entirely within Oregon, but the remaining tributaries span the state line. Birch and Pine creeks originate in Oregon, but their confluence with the Walla Walla River is in Washington. Cottonwood Creek flows into Yellowhawk Creek in Washington. Mill Creek originates in Washington, flows through Oregon for approximately six miles and enters the Walla Walla River in Washington, just west of the City of Walla Walla.

The Walla Walla River population is comprised of three historical MaSAs (Walla Walla, Mill and Pine) and two historical MiSAs (Dry and Switzler). Current spawning distribution is substantially reduced relative to the historical intrinsic distribution and is concentrated in the North and South forks of the Walla Walla River, Couse Creek, Mill Creek and Dry Creek (WA).

The Walla Walla Summer Steelhead population is at moderate risk based on current abundance and productivity. Spawner abundance in recent years has been moderately variable; the most recent 10-year geomean number of natural-origin spawners was 650. During the period 1993-2000, returns per spawner for steelhead in the Walla Walla River ranged from 0.39 (1993) to 2.65 (1998). The most recent 8-year (1993-2000) geomean of returns per spawner, delimited at the median and SAR adjusted was 1.34 (Appendix B).

The current point estimate for Abundance/Productivity on the viability curve for the Walla Walla River summer steelhead population falls between the 5% and 25% risk curves (Figure 6-10). This risk rating is based on a short data series, and should be viewed with caution.

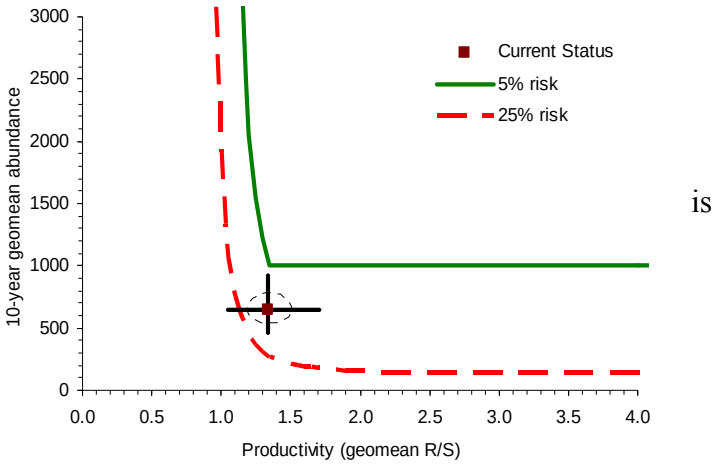


Figure 6-10. Walla Walla River Summer Steelhead population abundance and productivity compared to the viability curve for the DPS.

The integrated Spatial Structure/Diversity rating for the Walla Walla population is moderate risk. The rating for Goal A "allowing natural rates and levels of spatially mediated processes" was moderate risk. There has been significant reduction in spawner distribution that has resulted in increased gaps and loss of continuity within the population and between the Walla Walla population and other Mid-Columbia steelhead populations. The rating for Goal B "maintaining natural levels of variation" was moderate risk. Water temperature and hydrograph changes as well as barriers have likely influenced life history diversity and phenotypic expression. Out-of-

DPS spawners have put the population in the moderate risk category for the spawner composition metric. Within basin habitat changes have likely resulted in selective mortality at multiple life stages resulting in a moderate risk rating.

Overall Risk Rating
The Walla Walla Summer Steelhead population does not currently meet ICTRT criteria for viable status, although it does meet the criteria for a "maintained" population. The abundance/productivity values are at moderate risk and the time series is short resulting in considerable uncertainty. The 10-year geomean abundance of 650 is well below the minimum threshold of 1,000 for viable status. However, current abundance exceeds the 500 minimum recommended by the ICTRT for maintained status of an "intermediate" size population. We need additional brood years to demonstrate sustained recruits per spawner and abundance values above the low risk criteria level. Significant improvements to spatial structure and diversity are needed to improve the risk level.

6.11 Major Population Groups Viability Assessments

The status of each MPG is assessed based on the status of the constituent populations. Viability assessment findings for the three Mid-C steelhead MPGs that contain Oregon populations are summarized below.

Cascades Eastern Slope Tributaries MPG
To achieve viable status in the Cascades Eastern Slope Tributaries MPG, the Fifteenmile Creek, Deschutes River Eastside, Deschutes River Westside, and Klickitat populations must all achieve viable status. The Cascades Eastern Slope Tributaries MPG is below viable status because the Deschutes River Westside population did not meet viability criteria, and the Deschutes Crooked River population is extinct. (Table 6-1).

Table 6-1. Viability assessment results for Mid-C steelhead populations in the Cascades Eastern Slope Tributaries MPG.

Population	Extant/ Extinct	Abundance		Productivity		A/P Risk	Goal A Natural Processes Risk	Goal B Diversity Risk	Integrated SS/D Risk	Overall Population Viability Rating
		Mean	Lower 90% CI	Mean	Lower 90% CI					
Fifteenmile Creek	Extant	703	481	1.82	1.23	Low	Very Low	Low	Low	Viable
Deschutes River Eastside	Extant	1,599	896	1.89	1.10	Low	Low	Moderate	Moderate	Viable
Deschutes River Westside	Extant	456	306	1.05	0.76	High	Low	Moderate	Moderate	High Risk
Deschutes Crooked River	Extinct	0	NA	0	NA	Extinct	NA	NA	NA	Extinct

John Day River MPG
To achieve viable status in the John Day River MPG, the Lower Mainstem John Day River, North Fork John Day River, and either the Middle Fork John Day River or Upper Mainstem John Day River populations must achieve viable status. The John Day River MPG is below viable

status. The North Fork population is highly viable, however all of the other John Day River populations were below viable status (Table 6-2).

Table 6-2. Viability assessment results for Mid-C steelhead populations in the John Day River MPG.

Population	Extant/ Extinct	Abundance		Productivity		A/P Risk	Goal A Natural Processes Risk	Goal B Diversity Risk	Integrated SS/D Risk	Overall Population Viability Rating
		Mean	Lower 90% CI	Mean	Lower 90% CI					
Lower Mainstem John Day River	Extant	1,800	1,065	2.99	1.91	Moderate	Very Low	Moderate	Moderate	Maintained
North Fork John Day River	Extant	1,740	1,375	2.41	1.62	Very Low	Very Low	Low	Low	Highly Viable
Middle Fork John Day River	Extant	756	508	2.45	1.81	Moderate	Low	Low	Low	Maintained
South Fork John Day River	Extant	259	168	2.06	1.26	Moderate	Very Low	Low	Low	Maintained
Upper Mainstem John Day River	Extant	524	399	2.14	1.15	Moderate	Very Low	Moderate	Moderate	Maintained

Umatilla/Walla Walla Rivers MPG

To achieve viable status in the Umatilla/Walla Walla Rivers MPG, the Umatilla River population and either the Walla Walla River or Touchet River population must achieve viable status. The Umatilla/Walla Walla Rivers MPG is below viable status because neither the Umatilla River or Walla Walla River populations meet viability criteria (Table 6-3).

Table 6-3. Viability assessment results for Mid-C steelhead populations in the Umatilla/Walla Walla Rivers MPG.

Population	Extant/ Extinct	Abundance		Productivity		A/P Risk	Goal A Natural Processes Risk	Goal B Diversity Risk	Integrated SS/D Risk	Overall Population Viability Rating
		Mean	Lower 90% CI	Mean	Lower 90% CI					
Willow Creek	Extinct	0	NA	0	NA	Extinct	NA	NA	NA	Extinct
Umatilla River	Extant	1,472	988	1.50	1.11	Moderate	Moderate	Moderate	Moderate	Maintained
Walla Walla River	Extant	650	459	1.34	1.05	Moderate	Low	Moderate	Moderate	Maintained

6.12 DPS Viability Assessment

All major population groups must achieve viable status for the DPS to be considerable viable. The Mid-C steelhead DPS is below viable status because none of the MPGs currently achieve viable status.

Section 7 Viability Gaps

In the previous two sections we described viability criteria and presented results of the current status assessments. The status assessments provide a visual and narrative comparison of the current status relative to the abundance/productivity and spatial structure/diversity criteria. In this section, we present the results of ICTRT (2007a) abundance/productivity gap analysis and our spatial structure/diversity gap analyses.

7.1 Gaps Approach

This section provides a brief overview of the methods to establish a general understanding of the approach. Detailed methods for abundance/productivity gaps determination are provided in ICTRT (2007a).

The abundance/productivity gap is defined as the quantitative relative amount of change in survival or capacity that is required for a population to improve from current status to a specific viability level. The purpose of determining gaps is to inform planners and managers how much change is required to improve current status to a specific viability level. Observed gaps represent the amount of improvement needed assuming that the climate/environmental conditions and average survivals that occurred during the time period of the status assessments (generally 1980-2001) will be the same in the future. The gap analysis provides estimates of the magnitude of survival or capacity change that are needed to reach viability criteria for 25% (moderate risk), 5% (low risk) and 1% (very low risk) probability of extinction over a 100-year timeframe as defined by the viability curves. Beyond estimating observed gaps, the ICTRT used a modeling approach to evaluate the influence of alternative climate regimes and hydrosystem scenarios on observed gaps.

We only present observed gaps in this section. The influence of alternative ocean survival scenarios, hydrosystem scenarios, and other management actions on observed gaps is presented in Section 10 "Management Action Effectiveness." In addition to the gaps calculated for the current A/P status point estimate, gaps are also calculated to address the uncertainty criteria. Estimates of current abundance and productivity of a population are based on sampling data and are therefore subject to statistical uncertainty. The level of uncertainty, especially for the productivity, can have a substantial impact relative to confidence in the empirical difference between current status and specific risk levels. We incorporate an uncertainty gap into our analyses to minimize the potential of a substantial underestimate in the gap between the current A/P estimate and the specific risk levels. For Mid-C steelhead, we applied the following uncertainty criteria in our viability assessments: To achieve the 5% risk criteria (low risk), the lower end of the productivity 90% confidence interval needed to be above the 25% risk curve; and, to meet the 1% risk criteria (very low risk), the lower end of the 98% confidence interval needed to be above the 25% risk curve. We calculated gaps for both the 5% and 1% uncertainty criteria.

The ICTRT described a four-step process for determining observed abundance/productivity gaps. We summarize the steps below and encourage readers to view ICTRT (2007a) for a more extensive explanation.

1. *Estimate current intrinsic productivity and natural-origin abundance* (method previously described).

2. *Estimate adult spawner population size that achieves juvenile production capacity*. The ICTRT used population specific stock recruitment data fitted to a Hockey-Stick function to estimate current capacity. The full range of data for each population was used in the analyses. Simple cohort analyses were used to generate broodyear specific estimates of spawners. Spawner numbers were standardized to reflect average recent SARs and harvest rates to remove the substantial variation in ocean survival and harvest rates. Population specific estimates of spawners at capacity were highly variable. To address the effects of sampling variability, populations were grouped by species and the estimated capacity was regressed against the independent estimates of capacity derived from the intrinsic habitat potential analyses. The ultimate estimate of capacity was derived as the mean of the population specific stock-recruitment estimate and the corresponding regression-based estimate. This estimate is referred to as Model Capacity in the equations below.

3. *Assign populations to categories based on the point estimate position relative to the abundance/productivity variability curve*. Many of the Oregon Mid-C steelhead populations clustered together in a zone (ICTRT Zone C) where the abundance/productivity point estimates fell below the viability curve, substantially to the right (greater than) of the minimum productivity values. Those Mid-C steelhead populations that did not reside in Zone C were populations that had either abundance/productivity point estimates above the viability curve including Fifteenmile Creek, Deschutes River Eastside, and North Fork John Day River, or productivity and abundance values below the minimum criteria including the Deschutes River Westside population.

4. *Calculate the gap as the minimum distance for the current abundance/productivity point estimate (observed gap) to each viability curve and from the lower end of the 90% and 98% CI's to the 25% risk curve*. In cases where the uncertainty criteria gap was greater than the A/P point estimate gap, the uncertainty criteria gap was used. All of the Oregon Mid-C populations that did not meet A/P viability criteria, except the Deschutes River Westside population, exhibited current productivity above minimums needed at threshold abundance with recent average abundance below the threshold. The ICTRT concluded that these populations were strongly affected by density dependence.

The method for calculating gaps for populations with moderate to high productivity and relatively low abundance is detailed in ICTRT 2007a. The gaps are estimated based on estimated difference in observed abundance and estimated capacity relative to the threshold abundance level specific to the population.

The gap was calculated as:

Survival Gap = Threshold Abundance ÷ EQ capacity – 1
where EQ Capacity = Model Capacity + 10-year geomean abundance ÷ 2

The calculated gaps are expressed as the proportional increase in productivity, but can also be considered the proportional increases needed in effective capacity of the population. Because the threshold abundance levels are equal at the 5% and 1% risk levels, populations that reside in Zone C have the same point estimate gaps at these two risk levels.

Uncertainty gaps are calculated in a different way because they only address required changes in productivity. Uncertainty gaps are calculated as the relative proportional change in productivity required to move the lower end of the 90% confidence interval to the 25% risk curve for the low risk criteria, and to move the lower end of the 98% confidence interval to the 25% risk curve for the very low risk criteria.

The ICTRT has not provided specific guidance on how to define Spatial Structure/Diversity gaps; therefore we developed the following steps and criteria for identifying these gaps.

1) Identify for each population all spatial structure and diversity metrics with ratings of moderate or high risk.
2) For the metrics rated moderate, determine if the rating is a result of changed status from intrinsic conditions or if the rating is a result of an intrinsic moderate risk for the metric.
3) Characterize spatial structure and diversity gaps for each population as those metrics that are rated high risk and those metrics that are rated moderate risk because the current status is impaired relative to the intrinsic condition.

7.2 Population Specific Viability Gaps

The results of gaps analyses for Oregon Mid-C steelhead populations are discussed below and shown in Table 7-1.

7.2.1 Fifteenmile Creek Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 703 spawners exceeds the minimum threshold abundance of 500. The current productivity estimate of 1.82 recruits per spawner resides between the 5% and 1% risk curves. There is no observed gap or uncertainty gap for the 5% risk level. The observed and uncertainty gaps for the 1% risk level are 0.03 and 0.09 respectively (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was low risk. All of the Spatial Structure and Diversity metrics were rated very low or low risk, therefore there are no Spatial Structure/Diversity gaps for this population.

Table 7-1. Abundance/Productivity statistics, risk ratings, and observed and uncertainty gaps for Oregon Mid-C Steelhead populations. Observed gaps are calculated from current status point estimates. Uncertainty gaps are for achieving uncertainty criteria and are only presented when they exceed the observed gaps. Negative gaps indicate that current abundance/productivity exceeds the criteria. Gap data are from ICTRT (2007a).

	Current Status		Equilibrium	A/P Risk	SS/D Risk	Gaps				
						Observed (point estimate)			Uncertainty	
Population	Abundance	Productivity	Abundance	Rating	Rating	25%	5%	1%	5%	1%
Fifteenmile Cr.	703	1.82	632	Low	Low	-.41	-.21	.03		.09
Deschutes R. Eastside	1,599	1.89	1,501	Low	Moderate	-.46	-.34	-.20		.05
Deschutes R. Westside	456	1.05	448	High	Moderate	.14	.78	.92		
Lower Mainstem John Day R.	1,800	2.99	2,019	Moderate	Moderate	.00	.11	.11		
North Fork John Day R.	1,740	2.41	1,689	Very Low	Low	-.58	-.49	-.38		
Middle Fork John Day R.	756	2.45	928	Moderate	Low	.00	.08	.08		
South Fork John Day R.	259	2.00	409	Moderate	Low	-.02	.22	.22		.23
Upper Mainstem John Day R.	524	2.14	730	Moderate	Moderate	-.02	.37	.37		
Umatilla River	1,472	1.50	1,371	Moderate	Moderate	-.32	.09	.09		
Walla Walla River	650	1.34	625	Moderate	Moderate	-.08	.34	.45		

7.2.2 Deschutes River Eastside Population Gaps

Abundance/Productivity

The recent 10-year geomean natural-origin abundance of 1,599 spawners substantially exceeds the minimum threshold abundance of 1,000. The current productivity estimate of 1.89 resides in the very low risk zone and, thus, there are no observed abundance/productivity gaps. The lower end of the productivity 98% confidence interval is below the 25% risk curve resulting in a 0.05 gap to meet uncertainty criteria for 1% risk level. The abundance/productivity dataset is a relatively short time series which results in a larger 90% CI than is typical of most other Oregon Mid-C populations. Additional brood years will likely decrease the uncertainty around the productivity point estimate (Table 7-1).

Spatial Structure/Diversity

The overall Spatial Structure/Diversity rating was moderate risk. Spatial structure/diversity gaps were identified for the following metrics:

Phenotypic variation

Metric rated moderate risk due to likely reduction in juvenile and adult migration patterns resulting from flow and temperature changes in tributary production areas.

Spawner composition

Out-of-DPS spawners. Metric rated high risk due to the high proportion of Snake River strays spawning naturally in the population.

Out-of-population spawners within the MPG. Metric rated moderate risk due to the proportion of Round Butte Hatchery fish spawning naturally in the population.

7.2.3 Deschutes River Westside Population Gaps

Abundance/Productivity

The recent 10-year geomean natural-origin abundance of 456 spawners is well below the abundance threshold of 1,000, the threshold abundance for currently available habitat. The current productivity estimate of 1.05 recruits per spawner is well below the minimum of 1.35 required at the threshold abundance. The observed gaps, that are greater than uncertainty gaps, for the 5% and 1% risk levels are 0.78 and 0.92 respectively. This gap is by far the largest observed gap of all the Oregon Mid-C populations. The large gap results from the substantial difference in the equilibrium abundance (448) and the threshold abundance, as well as the low productivity (Table 7-1).

Spatial Structure/Diversity

The overall Spatial Structure/Diversity rating was moderate risk. Spatial Structure/Diversity gaps were identified for the following metrics:

Spatial extent or range of population

Metric rated moderate risk because spawner distribution is substantially reduced from historical due to blocked access to Whychus Creek and the Metolius River.

Increase or decrease in gaps or continuity

Metric rated moderate risk due to loss of occupancy in areas above Pelton-Round Butte Complex.

Genetic variation

Metric rated moderate risk because there are limited genetics data available and the samples that have been analyzed show similarity to out-of-DPS hatchery strays.

Spawner composition

Out-of-DPS spawners. Metric rated high risk because out-of-DPS strays have comprised a significant proportion of the natural spawners in this population for many generations.

7.2.4 Lower Mainstem John Day River Population Gaps

Abundance/Productivity

The recent 10-year geomean natural-origin abundance of 1,800 spawners is 72% of the threshold abundance of 2,250. The current productivity of 2.99 recruits per spawner is well above the minimum required at threshold abundance to meet the 1% risk level. The lower end of the 98%

CI also resides above the minimum needed to meet the 1% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.11. This gap is a result of the difference in the equilibrium abundance (2,019) and the threshold abundance (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was moderate risk. Gaps were identified for the following Spatial Structure/Diversity metrics:

Major life history strategies
Metric rated moderate risk because habitat changes have resulted in reduced juvenile life history diversity and restricted summer rearing distribution.

Genetic variation
Metric rated moderate risk because there are no genetics data and due to potential genetic effects of the high proportion of out-of-DPS spawners.

Spawner composition
Out-of-DPS spawners. Metric rated high risk due to high proportion and increasing trend of out-of-DPS spawners.

7.2.5 North Fork John Day River Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 1,740 spawners exceeds the threshold abundance of 1,500. The current productivity of 2.41 recruits per spawner is well above the value needed to meet the 1% risk level. The lower end of the 90% CI resides above the 1% risk level. There are no abundance/productivity gaps for the 5% or 1% risk levels (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was low risk. All metrics were rated very low or low risk, except for the following:

Spawner composition
Out-of-DPS spawners. Metric rated high risk due to the high estimated proportion of Snake River hatchery strays within this population. In addition, there is considerable uncertainty regarding the hatchery fraction estimates for this population.

7.2.6 Middle Fork John Day River Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 756 spawners is 75.6% of the threshold abundance of 1,000. The current productivity of 2.45 recruits per spawner is above the minimum needed at threshold abundance. The lower end of the 90% CI is well above the 25% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.08. This gap is a result of the difference in equilibrium abundance (928) and threshold abundance (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was low risk. All metrics were rated very low or low risk, except for the following:

Spawner composition
Out-of-DPS spawners. Metric rated high risk due to the high estimated proportion of out-of-DPS strays within this population.

7.2.7 South Fork John Day River Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 259 spawners is 51.8% of the threshold abundance of 500. The current productivity of 2.00 recruits per spawner is greater than the minimum required at the abundance threshold. The lower end of the 90% CI extends well below the 25% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.22. Uncertainty gap for the 1% risk level is 0.23. The gaps are primarily a result of the difference between the equilibrium abundance (409) and the threshold abundance (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was low risk. All metrics were rated very low or low risk, except the following:

Spawner composition
Out-of-DPS spawners. Metric rated high risk due to the high estimated proportion of out-of-DPS strays within this population.

7.2.8 Upper Mainstem John Day River Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 524 spawners is only 52.4% of the threshold abundance of 1,000. The current productivity of 2.14 recruits per spawner is well above the minimum required at the threshold abundance. The lower end of the 90% CI resides above the 25% risk level. The observed abundance/productivity gap to reach the 5% and 1% risk levels is 0.37. The uncertainty gaps are less than the observed gaps. The gap is primarily a result of the difference in the equilibrium abundance (730) and threshold abundance (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was moderate risk. Gaps were identified for the following Spatial Structure/Diversity metrics:

Major life history strategies
Metric rated moderate risk due to reduced opportunities for juvenile movement patterns and reduced summer rearing distribution that has resulted from altered mainstem and tributary habitats.

Spawner composition
Out-of-DPS spawners. Metric rated high risk due to the high proportion of out-of-DPS strays and uncertainty in the estimates of hatchery fraction.

7.2.9 Umatilla River Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 1,472 spawners is 98.1% of the threshold abundance of 1,500. The current productivity of 1.50 recruits per spawner is above the minimum of 1.26 required at the threshold abundance. The lower end of the 90% CI resides slightly above the 25% risk level. The observed abundance/productivity gap for the 5% and 1% risk levels is 0.09. The uncertainty gaps are less than the observed gaps (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was moderate risk. Gaps were identified for the following Spatial Structure/Diversity metrics:

Spatial extent or range of population
Metric rated moderate risk because the current spawner distribution is substantially reduced from the historical distribution. Loss of spawning in the Butter Creek and McKay Creek watersheds has resulted in the reduced distribution. There is considerable uncertainty regarding occupancy of the Alder and Glade MaSAs.

Increase or decrease in gaps and continuity
Metric rated moderate risk because of increased gaps and changed continuity resulting from losses of occupancy in the Butter Creek and McKay Creek watersheds.

Major life history strategies
Metric rated moderate risk as a result of reduced opportunity for life history expression for juvenile and adult life stages. This reduced opportunity has resulted from significant habitat changes in the Umatilla Basin.

Phenotypic variation
Metric rated moderate risk due to effects of flow and temperature on adult and juvenile migration characteristics.

Spawner composition
Overall rating is high risk due to two moderate ratings for the component metrics.

Out-of-DPS spawners. Metric rated moderate risk due to the estimated level of strays observed at Three-mile Falls Dam over the last three generations.

Within-population spawners. Metric rated moderate risk due to the proportion and duration of Umatilla Hatchery fish spawning in the basin.

Selective change in Natural Processes-Habitat
Metric rated moderate risk due to the selective effects of tributary temperature and flow changes on juvenile and adult migration characteristics and the effect of mainstem Columbia River temperature and flow on adult migration, survival, and straying.

7.2.10 Walla Walla River Population Gaps

Abundance/Productivity
The recent 10-year geomean natural-origin abundance of 650 spawners is well below the threshold abundance of 1,000. The current productivity of 1.34 recruits per spawner is slightly less than the minimum of 1.35 required at the threshold abundance. The lower end of the 90% CI extends well below the 25% risk level. The observed gaps for abundance/productivity at the 5% and 1% risk levels were 0.34 and 0.45 respectively. The uncertainty gaps at the 5% and 1% risk levels were less than the observed gaps. These gaps should be viewed cautiously because there is only a short data series available to estimate productivity (Table 7-1).

Spatial Structure/Diversity
The overall Spatial Structure/Diversity rating was moderate risk. Gaps were identified for the following Spatial Structure/Diversity metrics:

Spatial extent or range of population
Metric rated moderate risk because the current distribution is substantially reduced from the historical distribution. Loss of spawning in the Pine Creek MaSA and Switzler MiSA has resulted in reduced distribution.

Increase or decrease in gaps and continuity
Metric rated moderate risk because of increased gaps and changed continuity resulting from loss of occupancy in the Pine Creek MaSA.

Major life history strategies
Metric rated moderate risk due to changes in juvenile and adult movement patterns as well as reduced juvenile rearing distribution relative to historical opportunities. The reduced life history strategies have resulted from significant flow and temperature changes within the basin.

Phenotypic variation
Metric rated moderate risk due to effect of flow and temperature changes on phenotypic variation. Adult and juvenile migration patterns have been significantly altered due to these habitat changes.

Spawner composition
Out-of-DPS spawners. Metric rated moderate risk due to the proportion and duration of out-of-DPS spawners in the population.

Selective change in Natural Processes-Habitat

Metric rated moderate risk due primarily to tributary flow and temperature effects on juvenile and adult migration and movement patterns and the effect of mainstem Columbia River temperature and flow effects on adult migration, survival, and straying.

Section 8 Limiting Factors and Threats

This section describes limiting factors and threats to the viability of Mid-C steelhead in Oregon. The limiting factors and threats analyses serve as an essential foundation for the development and prioritization of management actions across the entire lifecycle. Findings were identified based on many sources of information, including the Mid-C steelhead Expert Panel's report, subbasin plans, ODEQ reports, ICTRT reports, NOAA's limiting factors modules, ODFW reports, hydrosystem biological opinion remand documents, and numerous other sources.

Section 8.1 provides a broad level perspective of the primary limiting factors and threats across and within Oregon's Mid-C steelhead populations. This broader look is followed by more detailed, in-depth discussions of limiting factors and threats in Section 8.2 (Tributary Habitat), 8.3 (Hydrosystem), 8.4 (Estuarine and Plume Habitat), 8.5 (Harvest), 8.6 (Hatchery), 8.7 (Predation and Competition) and 8.8 (Climate Change).

8.1 Primary Limiting Factors and Threats Across and Within Populations

This section describes the primary factors and threats constraining the viability of Oregon's Mid-C steelhead populations throughout their life cycles. It summarizes the findings of the Mid-C Expert Panel, the Mid-C recovery planning team, other groups and published information regarding the significance of these various factors and threats both across and within the populations. We used the following definitions of limiting factors and threats for our assessment:

> **Limiting factors:** The physical, biological, or chemical conditions of the environment and associated ecological processes and interactions (e.g., habitat connectivity, water quality, physical habitat quality, etc.) that influence Mid-C steelhead viable salmonid population parameters, including abundance, productivity, spatial structure, and diversity.
>
> **Threats:** Human actions (e.g., fishing, operation of hatcheries, operation of hydrosystem, land use practices, etc.) or natural events (e.g., flood, drought, volcano, etc.) that cause or contribute to limiting factors. Threats may influence one or multiple life stages and may occur in the present or future or have occurred in the past.

The Mid-C Expert Panel, created by ODFW for this purpose, consisted of 12 biologists with significant knowledge of the limiting factors and threats influencing steelhead production in the Mid-C steelhead DPS. Panelists examined limiting factors and threats for the ten independent steelhead populations, and then identified common key and secondary threat themes for all of the populations. They used a systematic process, similar to a Delphi process, during their deliberations. The Panel's approach in their deliberations and findings are discussed in the report Limiting Factors and Threats to the Recovery of Steelhead in the Oregon Portion of the Mid-Columbia Distinct Population Segment: Results of Expert Panel Deliberations (Mid-C Expert Panel 2006).

8.1.1 Primary Limiting Factors and Threats across Populations

Several factors and threats play a critical role in restricting viability across Oregon's Mid-C steelhead populations.

Land Use
We acknowledge that land use practices have improved significantly over the past few decades. In the tributary watersheds land managers, local land owners, and others have improved habitat management in an effort to enhance watershed conditions to support steelhead recovery. Actions to improve watershed conditions from the uplands to the floodplain are allowing, in some cases, natural ecosystem functions to recover. Although many steps have been taken, there are many more needed to achieve recovery goals. Tributary habitat degradation from past and/or present land use remains a key concern for all of the populations. Steelhead have been adversely affected by modified and reduced streamflows, impaired water quality due to elevated water temperatures and agricultural chemicals, impaired upstream and downstream fish passage, degraded channel structure and complexity (including riffles, pools and large woody debris), loss of riparian vegetation, reduced floodplain connectivity, and excessive levels of fine sediments caused by altered sediment routing. Threats contributing to these factors include agricultural, forestry and grazing practices that negatively impact steelhead growth and survival, dams and other barriers, water withdrawals, roads and channel manipulations.

The Mid-C Expert Panel identified land use as having the most key concerns of any of the threat categories. Depending on the population, the Panel listed the following as either key or secondary concerns attributable to land use: 1) impaired upstream and downstream movement of juvenile and adult steelhead; 3) impaired physical habitat quality; 4) impaired water quality due to elevated water temperatures and agricultural chemicals; 5) reduced water quantity and/or modified hydrologic processes. Listed as secondary concerns for all populations were the impacts of fine sediment on steelhead eggs and alevins, and the impact of predation by birds on pre-smolts and smolts in the estuary as a result of habitat alterations resulting from the creation of dredge spoil islands. Panelists noted that current land use practices are considerably improved over historical practices.

Hatcheries
Out-of-DPS hatchery strays pose significant risk to several of Oregon's Mid-C steelhead populations, particularly to the Eastside and Westside Deschutes and John Day populations. Viability assessments, summarized in Section 6 of this document and presented in Appendix B, identified that a significant proportion of spawners in the Deschutes River and John Day River populations were out-of-DPS strays. In addition, these populations were rated at high risk for spawner composition due to the abundance of strays. Biologists remain especially concerned regarding the continuing detrimental impact of stray out-of-DPS hatchery fish in natural spawning areas on the genetic traits and productivity of these natural populations. Hatchery programs operated within the Mid-C steelhead DPS — including the Umatilla, Walla Walla and Westside Deschutes subbasins — also create some risks. The Mid-C Expert Panel ranked the impact of hatchery strays as a key concern to the Eastside and Westside Deschutes and Lower John Day populations, and as a secondary concern to the Umatilla and Walla Walla populations.

Hydrosystem
The mainstem Columbia River hydrosystem is considered a primary threat to the viability of Oregon's Mid-C steelhead populations. Specific viability concerns identified by the Mid-C Expert Panel related primarily to effects of delayed upstream passage (adults), direct and indirect mortality on downstream migrants (juveniles), alteration of the hydrograph (mainstem and estuary flow regime), depletion of historically available nutrients, and degraded rearing and food resources for both presmolts and smolts in the Columbia.

Results of the BiOp Framework Work Group support this conclusion. This work group was created by NMFS to provide scientific expertise during development of its Biological Opinion (BiOp) evaluating effects of operations of the FCRPS. One work group task was to estimate the relative magnitude of human-caused mortality factors influencing Interior Columbia River salmon and steelhead populations, including Mid-C steelhead. During this evaluation, the work group found that the FCRPS hydrosystem had the greatest relative impact on the Mid-C steelhead populations compared with other human-induced mortality effects (Step 4 Report 2006) (Table 8-1). The ICTRT reached a similar conclusion in September 2006, when members rated the mainstem Columbia River hydrosystem as a major limiting factor for all populations in the DPS. Oregon's recovery planning team also determined that the mainstem hydropower system represents a primary threat to the viability of Oregon Mid-C steelhead populations. The Expert Panel's findings were generally consistent with the BiOp Framework Work Group's findings on magnitude of human-induced mortality, however, the Expert Panel considered the mainstem Columbia hydrosystem a threat of moderate concern to the populations and generally considered legacy and current land use as a greater threat than the hydrosystem.

Impacts from the mainstem Columbia River hydrosystem increase somewhat for each of the populations in direct relation to the number of dams the fish must pass during their migration to and from the Pacific Ocean. Oregon's Mid-C steelhead populations pass from one to four Columbia River dams: the Fifteenmile Creek population passes one dam; Deschutes River populations pass two dams; John Day River and Umatilla River populations pass three dams; and the Walla Walla River population passes four dams.

Several hydroelectric dams on Columbia River tributaries also pose significant threats to the viability of specific populations. The Expert Panel listed the impact of the Pelton-Round Butte Complex as a key concern for Westside Deschutes and Crooked River populations

Harvest
Given current management regulations for mainstem Columbia River and tributary fisheries, harvest is not considered a primary or secondary threat due to the low impact on viability. The ICTRT identified harvest-related effects as a secondary level limiting factor and the Mid-C Expert panel did not identify harvest as either a key or secondary concern for Oregon's Mid-C steelhead populations. The panel, however, did express concerns over the impact that mortality associated with catch and release fisheries have on Westside and Eastside Deschutes populations.

Predation
Predation by non-native piscivorous fish on pre-smolts and smolts in the mainstem Columbia was listed by the Expert panel as a secondary concern for all Mid-C steelhead populations.

Predation is a primary concern for juvenile and adult steelhead in the Columbia River estuary and plume. Estuary habitat modifications have increased the number and/or predation effectiveness of Caspian terns, cormorants, and gull species (Fresh et al. 2005). The increasing abundance of native pinnipeds has resulted in increased predation on adult salmonids to a point of concern.

Table 8-1. Ranges of proportional reduction in survival for human-induced mortality factors that influence Oregon's Mid-Columbia River steelhead. Negative values are truncated to zero (Step 4 Report 2006).

Location Population	FCRPS Hydro (juvenile)	FCRPS Hydro Latent	FCRPS Hydro (adult)	Tribal In-River Harvest	Non-Tribal In-River Harvest	Indirect and Additional Harvest	Tributary Habitat	Tributary Habitat Delayed	Hatchery	Estuary	Avian Estuary Predation (smolts)	Pinniped Predation (adult)
Above McNary Dam Walla Walla River	.47	.05 -.29	0 -.02	0 -.10	.03	0 -.07	.25	0 -.03	.02 -.05	.04	.12	.05
Above John Day Dam Umatilla River John Day Subbasin (5 populations)	.39	.06 -.22	0 -.02	0 -.10	.03	0 -.07	.25	0 -.03	.02 -.05	.04	.12	.05
Above The Dalles Dam Deschutes River (2 populations)	.24	.08 -.15	0 -.02	0 -.10	.03	0 -.07	.20	0 -.03	.02 -.05	.04	.12	.05
Above Bonneville Dam Fifteenmile Creek	.15	.08	0 -.02	0 -.10	.03	0 -.07	.20	0 -.03	.02 -.05	.04	.12	.05

8.1.2 Primary Limiting Factors and Threats Within Populations

During the recovery planning process, the recovery planning team and the Mid-C Expert Panel conducted separate evaluations of limiting factors and threats for the ten independent steelhead populations throughout their life cycles, and then identified the primary, or key and secondary, constraints limiting population viability. The limiting factors and threats assessment in this plan reflects information gained from many sources including subbasin plans, water quality reports, ICTRT assessments, NOAA limiting factors modules and ODFW reports. The results from the two evaluations, which are generally similar, are summarized below.

Fifteenmile Creek Winter Steelhead Population
The Mid-C recovery planning team identified the following limiting factors and threats to the Fifteenmile Creek steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat*: low flows, high water temperatures, degraded riparian condition, sediment routing, degraded floodplain, degraded channel structure (channel confinement and overall habitat diversity); *Hydro:* mainstem passage.
>
> **Primary Threats:** Current land use practices (including roads, residential development, agricultural practices and forest practices) and the Columbia River mainstem hydropower system.
>
> **Primary Life Stages Affected:** Fry, summer parr, winter parr, smolts.
>
> **VSP Characteristics Impacted:** Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current land use practices are the primary threat to the viability of the Fifteenmile Creek steelhead population (Table 8-2).

Table 8-2. Key and secondary threats to viability of the Fifteenmile Creek steelhead population (Mid-C Expert Panel 2006).

Fifteenmile Creek
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected:* Impaired physical habitat quality; elevated water temperatures; agricultural chemicals in tributaries; reduced water quantity and/or modified hydrograph. • *Life stage(s) primarily affected:* fry, summer parr and winter parr. • *Specific threat(s):* Current land use practices (agriculture, and forest practices, road maintenance) that negatively impact steelhead growth and survival in tributary streams. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: Direct mortality of pre-smolts and smolts at dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. **Land Use Practices:** Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from past and present agricultural and forestry practices reduces survival of eggs and alevins in tributary streams. **Introduced Species:** Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

Deschutes River Eastside Summer Steelhead Population
The Mid-C recovery planning team identified the following limiting factors and threats to the Deschutes River Eastside steelhead population:

> **Primary Limiting Factors**: *Tributary Habitat*: degraded riparian condition, low flows, high water temperatures, degraded channel structure/complexity and floodplain connectivity, impaired fish passage; *Hatchery*: effects of naturally spawning stray hatchery fish on viability; *Hydro*: mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high proportions of stray hatchery fish in natural spawning areas; current land use practices (grazing, roads, residences, forestry and agricultural practices that simplify habitats and irrigation withdrawals); the Columbia River mainstem hydropower system.
>
> **Primary Life Stages Affected:** Spawners, fry, summer parr, winter parr, smolts.
>
> **VSP Characteristics Impacted:** Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current hatchery and land use practices are the primary threats to the viability of the Deschutes River Eastside steelhead population (Table 8-3).

Table 8-3. Key and secondary threats to viability of the Deschutes River Eastside steelhead population (Mid-C Expert Panel 2006).

Deschutes – Eastside Tributaries
Key Threats
Current Hatchery Practices • *Limiting factor(s) primarily affected:* Straying of hatchery steelhead into spawning grounds. • *Life stage(s) primarily affected:* Spawners. • *Specific threat(s):* Management designed to produce returns of hatchery summer steelhead to the Deschutes and many other upstream Columbia River tributaries results in significant proportions of stray hatchery steelhead spawning naturally in this population. The principal concern relates to a continuing detrimental impact of stray hatchery fish in natural spawning areas on the genetic traits and productivity of naturally produced steelhead. **Current Land Use Practices** • *Limiting factor(s) primarily affected:* Reduced water quantity and/or modified hydrograph; impaired physical habitat quality; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Current land use practices (agriculture, grazing, forest practices, road maintenance, etc.) that impact steelhead growth and survival, or modify natural hydrographs during critical periods in tributary streams. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: (See discussion for Fifteenmile Creek population.) **Land Use Practices:** (See discussion for Fifteenmile Creek population.) **Harvest:** Mortality of returning adults in tributary streams from catch and release fishery. **Introduced Species***:* (See discussion for Fifteenmile Creek population.)

Deschutes River Westside Summer Steelhead Population
The Mid-C recovery planning team identified the following limiting factors and threats to the Deschutes River Westside steelhead population:

Primary Limiting Factors: *Tributary Habitat:* degraded channel structure and complexity, altered sediment routing, high water temperature, low flows and lack of fish passage over PRBC; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage and tributary passage to blocked areas above Pelton-Round Butte Complex.

Primary Threats: Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices (grazing, roads, residences, forestry and agricultural practices that simplify habitats and irrigation withdrawals); the Columbia River mainstem hydropower system.

Primary Life Stages Affected: Spawners, fry, summer parr, winter parr, smolts.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current hatchery practices, hydropower influences, and land use practices are the primary threats to the viability of the Deschutes River Westside steelhead population (Table 8-4).

Table 8-4. Key and secondary threats to viability of the Deschutes River Westside steelhead population (Mid-C Expert Panel 2006).

Deschutes – Westside Tributaries
Key Threats
Current Hatchery Practices • *Limiting factor(s) primarily affected:* Stray hatchery steelhead spawn with wild population. • *Life stage(s) primarily affected:* Spawners. • *Specific threat(s):* Management designed to produce returns of hatchery summer steelhead to the Deschutes and many other upstream Columbia River tributaries results in significant proportions of stray hatchery steelhead spawning naturally in this population. Straying of these hatchery fish into natural spawning areas threatens the genetic traits and productivity of naturally produced steelhead. **Current Hydropower:** • *Limiting factor(s) primarily affected:* Impaired downstream migration through Lake Billy Chinook; blocked migration above Pelton Dam. • *Life stage(s) primarily affected:* Smolts and returning adults. • *Specific threat(s):* Fish passage currently blocked at Pelton Dam on the Deschutes, eliminating access by steelhead to a significant portion of the historical distribution of this population. **Current Land Use Practices** • *Limiting factor(s) primarily affected:* Impaired physical habitat quality. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Current land use practices (agriculture, grazing, forestry, road maintenance) that negatively impact steelhead growth and survival in tributary streams. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: (See discussion for Fifteenmile Creek population.) **Land Use Practices***:* Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; elevated water temperatures and increased fine sediment from past and present agricultural and forestry practices reduce survival of eggs and alevins in tributary streams; reduced water quantity and/or modified hydrograph impacts growth and survival of fry and summer parr in tributaries. **Harvest***:* Mortality of returning adults in tributary streams from catch and release fishery. **Introduced Species***:* (See discussion for Fifteenmile Creek population.)

Crooked River Summer Steelhead Population

Members of the Mid-C recovery planning team identified the following limiting factors and threats to the Crooked River steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat*: degraded channel structure and complexity, floodplain connectivity, degraded riparian condition, altered sediment routing, high water temperatures, low flows, and passage barriers. *Hydro*: mainstem Columbia river passage and passage in the Deschutes River mainstem to blocked areas above Pelton-Round Butte Complex.
>
> **Primary Threats:** Current land use practices (including grazing, roads, residential development, forestry and agricultural practices that simplify habitats and irrigation withdrawals); the Pelton-Round Butte Complex and the Columbia River mainstem hydropower system; passage barriers that block access to tributary spawning and rearing habitat.
>
> **Primary Life Stages Affected:** Spawners, fry, summer parr, winter parr, smolts and adult migrants.
>
> **VSP Characteristics Impacted:** Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current land use practices and the Pelton-Round Butte Complex are primary threats to viability of the Crooked River steelhead population (Table 8-5).

Table 8-5. Key and secondary threats to viability of the extinct Deschutes Crooked River steelhead population (Mid-C Expert Panel 2006).

Deschutes – Crooked River (Extinct population)
Key Threats
Current Hydropower • *Limiting factor(s) primarily affected:* Impaired downstream migration; blocked upstream migration, hydrograph, water quantity. • *Life stage(s) primarily affected:* smolts and returning adults. • *Specific threat(s):* Fish passage is currently blocked at Pelton Dam on the mainstem Deschutes, thereby entirely eliminating access by steelhead to the historic distribution of this population. **Current Land Use Practices/Irrigation System** • *Limiting factor(s) primarily affected*: Fish migration; impaired physical habitat quality; elevated water temperatures; reduced water quantity and/or modified hydrograph, population traits. • *Life stage(s) primarily affected:* fry, summer parr, winter parr, adults. • *Specific threat(s):* Current land use practices (agriculture, grazing, forestry, road maintenance, etc.) that impact steelhead growth and survival in tributaries; irrigation diversions. These conditions would impair the likelihood of re-establishing a self-sustaining population of steelhead in the future. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historic practices. Maintenance of an irrigation water storage system in the Crooked River alters the seasonal hydrograph (lower summer flows, higher autumn flows) and increases summer water temperatures. These conditions would impair the likelihood of re-establishing a self-sustaining population of steelhead in the future.
Secondary Threats
Current Mainstem Columbia Hydropower System: Direct mortality of pre-smolts and smolts at The Dalles and Bonneville dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. **Land Use Practices***:* Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from past and present agricultural and forestry practices reduce survival of eggs and alevins in tributary streams. **Introduced Species:** Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

Lower Mainstem John Day River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the Lower Mainstem John Day River steelhead population:

Primary Limiting Factors: *Tributary Habitat*: degraded channel structure and complexity (habitat quantity and diversity), altered sediment routing, water temperature, and altered hydrology. Impaired fish passage is also a high priority limiting factor in Bridge, Butte, Kahler, Muddy, Rock, and Thirtymile creeks; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.

Primary Threats: Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices (agricultural and grazing practices, removal of overstory trees and bank vegetation from the riparian corridor, water withdrawals, wetland draining and conversion, and stream channelization and diking; the Columbia River mainstem hydropower system.

Primary Life Stages Affected: Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, smolts.

VSP Characteristics Impacted: Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current hatchery and land use practices are the primary threats to viability of the Lower Mainstem John Day River steelhead population (Table 8-6).

Table 8-6. Key and secondary threats to viability of the Lower Mainstem John Day River steelhead population (Mid-C Expert Panel 2006).

John Day River – Lower Mainstem
Key Threats
Current Hatchery Practices • *Limiting factor(s) primarily affected:* Straying of hatchery steelhead into tributaries. • *Life stage(s) primarily affected:* Spawners. • *Specific threat(s):* Management designed to produce returns of hatchery summer steelhead to upstream Columbia River tributaries results in significant proportions of stray hatchery steelhead spawning naturally in this population. Straying of hatchery fish into natural spawning areas poses risks to the genetic traits and productivity of naturally produced steelhead. **Current Land Use Practices** • *Limiting factor(s) primarily affected:* Impaired physical habitat quality; elevated water temperatures. • *Life stage(s) primarily affected:* Fry, summer parr and winter parr. • *Specific threat(s):* Past and/or current land use practices (agriculture, grazing, forest practices) that impart steelhead growth and survival in tributaries. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: Direct mortality of pre-smolts and smolts at John Day, The Dalles and Bonneville dams; delayed upstream migration of returning adults over dams; false attraction of returning adults over Mc Nary Dam; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. **Land Use Practices**: Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary from creation of dredge spoil islands; increased fine sediment from agricultural and forestry practices reduces egg and alevin survival tributaries; reduced water quantity and/or modified hydrograph that impact growth and survival of fry and summer parr in tributaries. **Introduced Species**: Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

North Fork John Day River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the North Fork John Day River steelhead population:

> **Primary Limiting Factors**: *Tributary Habitat*: degraded floodplain connectivity and function, degraded channel structure and complexity (key habitat quantity, habitat diversity, channel stability), altered sediment routing, water temperature, and low flows; *Hatchery*: effects of naturally spawning stray hatchery fish on viability; *Hydro*: mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices (riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, irrigation withdrawals, mining and dredging); the Columbia River mainstem hydropower system.
>
> **Primary Life Stages Affected:** Parr-to-smolt survival, egg-to-fry survival, smolts.
>
> **VSP Characteristics Impacted:** Abundance, productivity, diversity.

The Mid-C Expert Panel (2006) concluded that current land use practices are the primary threat to viability of the North Fork John Day River steelhead population (Table 8-7).

Table 8-7. Key and secondary threats to viability of the North Fork John Day River steelhead population (Mid-C Expert Panel 2006).

John Day River – North Fork
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected*: Impaired physical habitat quality; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Past and current land use practices (agriculture, grazing, forestry, road maintenance) that impact steelhead growth and survival in tributary streams. Improvement of some habitat conditions is expected in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: (See discussion for Lower Mainstem John Day population.) **Land Use Practices**: (See discussion for Lower Mainstem John Day population.) **Introduced Species**: (See discussion for Lower Mainstem John Day population.)

Middle Fork John Day River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the Middle Fork John Day River steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat:* degraded channel structure and complexity (habitat quantity and diversity), degraded floodplain function and connectivity, altered sediment routing, altered hydrology, and water temperature; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices (riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, passage barriers, irrigation withdrawals, mining and dredging); the Columbia River mainstem hydropower system.
>
> **Primary Life Stages Affected:** fry-to-smolt, egg incubation; egg-to-parr, smolts, adult spawning.
>
> **VSP Characteristics Impacted:** Abundance, productivity, diversity.

The Mid-C Expert Panel (2006) concluded that current land use practices are the primary threat to viability of the Middle Fork John Day River steelhead population (Table 8-8).

Table 8-8. Key and secondary threats to viability of the Middle Fork John Day River steelhead population (Mid-C Expert Panel 2006).

John Day River – Middle Fork
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected*: Impaired physical habitat quality; elevated water temperatures • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Past and current practices (grazing, forest practices, road maintenance) that impact steelhead growth and survival in tributaries. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: (See discussion for Lower Mainstem John Day population.) **Land Use Practices**: (Factors identified in discussion for Lower Mainstem John Day population, plus push-up dams that impair upstream passage of returning adults and upstream and downstream movement of fry and summer parr.) **Introduced Species**: (See discussion for Lower Mainstem John Day population.)

South Fork John Day River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the South Fork John Day River steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat*: altered sediment routing, degraded channel structure and complexity (habitat quantity and diversity), altered hydrology and low flow, water temperature, and impaired fish passage; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices (riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, fish passage barriers (culverts, and other seasonal barriers), and irrigation withdrawals); the Columbia River mainstem hydropower system.
>
> **Primary Life Stages Affected:** Juvenile rearing, adult spawning, egg incubation, egg-to-parr survival, smolts.
>
> **VSP Characteristics Impacted:** Abundance, productivity, diversity.

The Mid-C Expert Panel (2006) determined that current land use practices pose the primary threat to viability of the South Fork John Day River steelhead population (Table 8-9).

Table 8-9. Key and secondary threats to viability of the South Fork John Day River steelhead population (Mid-C Expert Panel 2006).

John Day River – South Fork
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected:* Reduced water quantity and/or modified hydrograph; impaired physical habitat quality; impaired fish passage; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr, returning adults. • *Specific threat(s):* Current land use practices (agriculture, push-up dams that provide irrigation water, grazing, etc.) that impact steelhead growth and survival in tributaries; push-up dams that block or impair fish movement. Improvement of some habitat conditions is expected in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: (See discussion for Lower Mainstem John Day population.) **Land Use Practices**: Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from agricultural and forestry practices reduces egg and alevin survival tributaries. **Introduced Species**: (See discussion for Lower Mainstem John Day population.)

Upper Mainstem John Day River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the Upper Mainstem John Day River steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat:* degraded channel structure and complexity (habitat quantity and diversity), degraded riparian areas and LWD recruitment, altered sediment routing, water temperatures, altered hydrology and degraded floodplain function and connectivity. Impaired fish passage is also a priority limiting factor in Beech and Laycock creeks; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices (agricultural practices, livestock overgrazing, removal of large trees from the riparian corridor, wetland draining and conversion, stream channelization/diking); the Columbia River mainstem hydropower system.
>
> **Primary Life Stages Affected:** Juvenile rearing, egg incubation, egg-to-parr survival, smolts, adult spawning.
>
> **VSP Characteristics Impacted:** Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current land use practices pose the primary threat to viability of the Upper Mainstem John Day River steelhead population (Table 8-10).

Table 8-10. Key and secondary threats to viability of the Upper Mainstem John Day River steelhead population (Mid-C Expert Panel 2006).

John Day River – Upper Mainstem
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected:* Reduced water quantity and/or modified hydrograph; impaired physical habitat quality; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Current land use practices (agriculture, forestry, push-up dams that provide irrigation water, grazing, etc.) that impact steelhead growth and survival in tributaries. Improvement of some habitat conditions is expected in the future due to current practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: (See discussion for Lower Mainstem John Day population.) **Land Use Practices**: (See discussion for South Fork John Day population.). **Introduced Species**: (See discussion for Lower Mainstem John Day population.)

Umatilla River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the Umatilla River steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat*: high water temperature, sediment routing, impaired fish passage, degraded channel structure and complexity and low flows; *Hatchery*: effects of naturally spawning stray hatchery fish on viability; *Hydro*: mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices that reduce habitat quality, quantity and disrupt ecosystem functions; the Columbia River hydropower system.
>
> **Primary Life Stages Affected:** fry, summer parr, winter parr, smolts.
>
> **VSP Characteristics Impacted:** Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current land use practices pose the primary threat to viability of the Umatilla steelhead population (Table 8-11).

Table 8-11. Key and secondary threats to viability of the Umatilla River steelhead population (Mid-C Expert Panel 2006).

Umatilla
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected:* Reduced water quantity and/or modified hydrograph; impaired physical habitat quality; impaired fish movement and habitat access; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Current land use practices (agriculture, un-screened irrigation diversions, maintenance of the irrigation impoundment system that provides irrigation water and flow control, forest practices, grazing) that impact steelhead growth and survival in tributaries. Improvement of some habitat conditions is expected to occur in the future, based on current land use practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: Direct mortality of pre-smolts and smolts at John Day, The Dalles and Bonneville dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. **Hatchery Practices**: Stray hatchery steelhead spawn in tributaries with wild population creating a risk of genetic introgression. **Land Use Practices**: Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from agricultural and forestry practices reduces egg and alevin survival in tributaries. **Introduced Species**: Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

Walla Walla River Summer Steelhead Population

The Mid-C recovery planning team identified the following limiting factors and threats to the Walla Walla River steelhead population:

> **Primary Limiting Factors:** *Tributary Habitat*: high water temperature, sediment routing, impaired fish passage, degraded channel structure and complexity, degraded floodplain connectivity and function, and low flow; *Hatchery:* effects of naturally spawning stray hatchery fish on viability; *Hydro:* mainstem passage.
>
> **Primary Threats:** Hatchery management that results in high rates of straying hatchery fish in natural spawning areas; current land use practices that reduce habitat quality, quantity and disrupt ecosystem functions; the Columbia River mainstem hydrosystem.
>
> **Primary Life Stages Affected:** fry, summer parr, winter parr, smolts.
>
> **VSP Characteristics Impacted:** Abundance, productivity, spatial structure, diversity.

The Mid-C Expert Panel (2006) determined that current land use practices pose the primary threat to viability of the Walla Walla River steelhead population (Table 8-12).

Table 8-12. Key and secondary threats to viability of the Walla Walla River steelhead population (Mid-C Expert Panel 2006).

Walla Walla
Key Threats
Current Land Use Practices • *Limiting factor(s) primarily affected*: Reduced water quantity and/or modified hydrograph; impaired physical habitat quality; impaired fish movement and habitat access; elevated water temperatures. • *Life stage(s) primarily affected:* fry, summer parr, winter parr. • *Specific threat(s):* Current land use practices (agriculture, un-screened irrigation diversions, push-up dams, maintenance of the irrigation impoundment system that provides irrigation water and flow control, forest practices, grazing) that impair steelhead growth and survival in tributaries. Improvement of some habitat conditions is expected in the future, based on current practices that are much improved over historical practices.
Secondary Threats
Current Mainstem Columbia Hydropower System: Direct mortality of pre-smolts and smolts at John Day, The Dalles and Bonneville dams; delayed upstream migration of returning adults over dams; cumulative impact of system on mainstem and estuary habitat for pre-smolts and smolts. **Hatchery Practices**: Stray hatchery steelhead spawn in tributaries with wild population creating a risk of genetic introgression. **Land Use Practices**: Cumulative impact of past and present activities on estuarine habitat for pre-smolts and smolts; predation by birds on pre-smolts and smolts in estuary because of creation of dredge spoil islands; increased fine sediment from agricultural and forestry practices reduces egg and alevin survival in tributaries. **Introduced Species**: Predation by non-native piscivorous fish on pre-smolts and smolts in mainstem Columbia.

8.2 Tributary Habitat

Historically, habitat conditions in the Fifteenmile, Deschutes, John Day, Umatilla, and Walla Walla subbasins supported productive and viable steelhead populations. Natural processes created diverse instream habitats with deep pools and strong connections to floodplains. Many stream channels contained abundant large wood from surrounding riparian hardwood galleries, including cottonwood, aspen, willow, and upstream conifer forests. Stream temperatures were generally sufficient to support all steelhead life stages throughout the year, as upland and riparian conditions allowed for the storage and release of cool water during the dry, summer months and provided shaded sufficient to keep water temperatures cool. Extensive and abundant riparian vegetation armored streambanks, providing protection against erosion.

Conditions in these tributary drainages have changed considerably over the last 150 years. Together, past land use practices across the region contributed significantly to causing the factors now limiting abundance, productivity, and diversity of Mid-C steelhead. As noted by the Expert Panel, and indicated by the EDT limiting factors analyses, historical spawning and rearing areas are now often degraded restricting steelhead abundance, productivity, spatial structure and diversity. However, while harmful land use practices continue today, many landowners now understand the advantages of good conservation practices and have changed their approaches to farming, grazing, forest practices and other activities so that important ecosystem processes and functions can recover. In addition, a suite of regulatory programs have been implemented to protect and restore steelhead habitat conditions. Many people are also voluntarily protecting and restoring stream corridors, wetlands, and other natural features that influence the viability of salmonid populations. Such changes are slowly improving habitat conditions for Mid-C steelhead and other species, while also restoring overall watershed health.

Nevertheless, two emerging threats — forest health and land use conversion — need to be acknowledged. Management actions of the past, including unregulated forest practices, poorly managed livestock grazing, and fire suppression have modified patterns of vegetation in forest and range habitats. These changes have resulted in alteration of important ecosystem processes such as fire, insects and succession. In some cases, current conditions are a significant departure from historical. Fire suppression and silvicultural practices in some Mid-C forests have modified the historical fire regimes and contributed to unnaturally heavy fuel loads. A significant proportion of the forested landscape in the Westside Deschutes, North Fork John Day, Middle Fork John Day, and Upper Mainstem John Day populations is now characterized by such conditions and is classified by the USFS (Schmidt et al. 2002) as condition class 3 with severely altered fire regimes and vegetation attributes significantly altered from the historical conditions (Figure 8-1). Unless improved, areas within these significantly altered landscapes will likely experience intensive wild fires that can impact steelhead recovery efforts, at least in the short term.

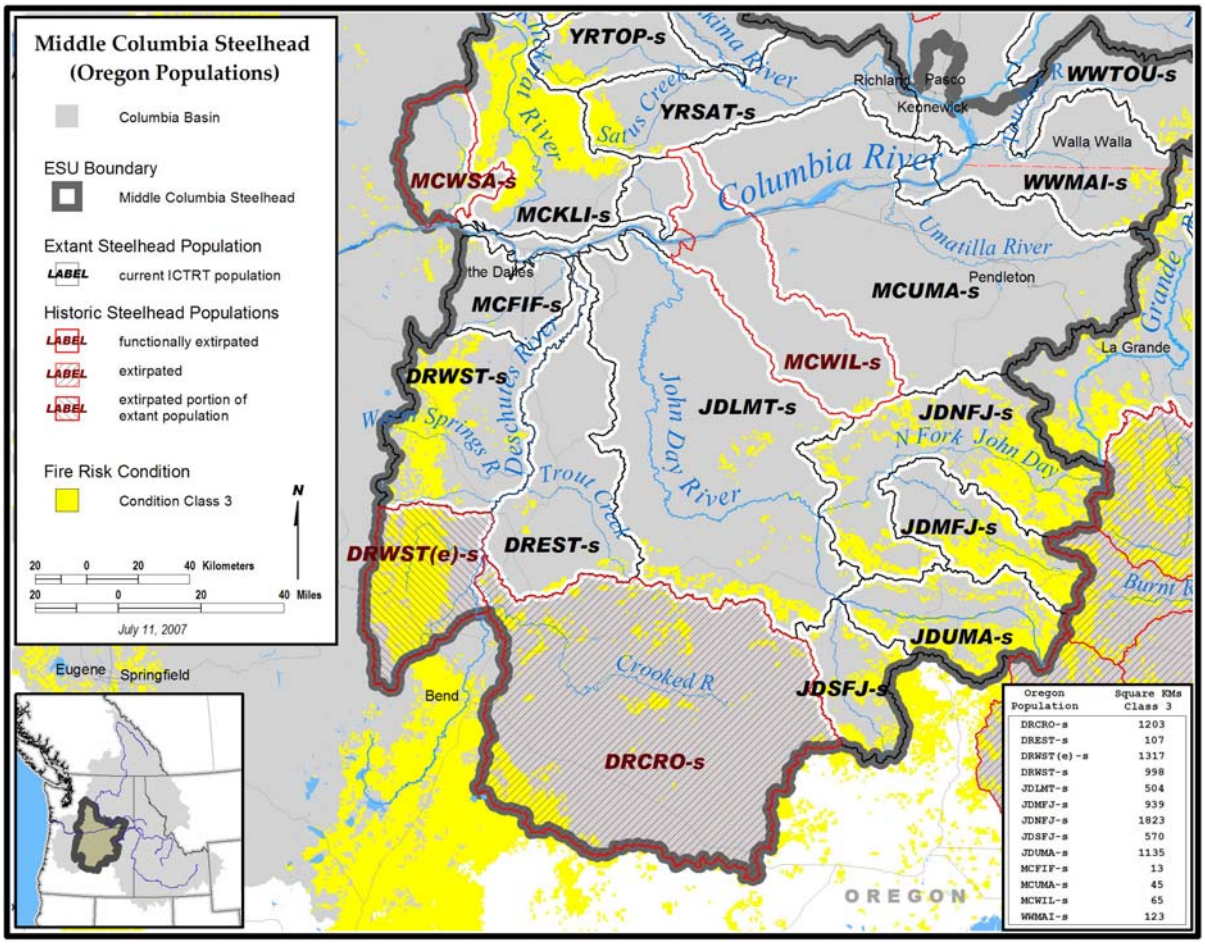


Figure 8-1. Areas within Oregon Mid-C steelhead populations that have significantly altered fire regimes and vegetative attributes that are altered from the historical condition (USFS condition class 3).

Although significant proportions of the forested landscape in these four populations are classified as condition class 3, the degree of threat to the viability of steelhead is uncertain. Much of the research over the past 15 years has demonstrated that, in general, episodic wildfires and post-fire flood events tend to produce long-term habitat benefits for salmonids. The immediate adverse impacts, when they occur, are relatively short term in duration (Howell, 2006; Rieman et al. 1997; Sestrick, 2005; Dunham et al. 2003). However, particularly after large intensive wildfires, water temperatures may increase where streamwide vegetation is destroyed and post-fire channel reorganizing flood events occur, though this does not occur in all cases. In cases where temperatures rise, they can remain elevated for periods of ten years or longer, but rainbow trout quickly repopulate such areas post-fire when fish passage has not been obstructed, and populations maintain their distributions (Dunham et al. 2007). Soil erosion and sediment losses may also increase significantly after intense wildfires, depending on area topography, precipitation, and restoration efforts, adversely impacting spawning and rearing habitats and increasing the short-term risks to viability of some populations (Rieman et al. 2000).

Strategic restoration efforts aimed at restoring such landscapes back to their natural vegetative conditions and their historical fire regimes could help enhance watershed function and forest health. Such approaches will most likely be effective only in areas where existing road systems can facilitate restoration activities without additional disturbance or impact (Rieman et al. 2000).

Rieman et al. (2000 and 2001) concluded that alteration of fire regimes did little to affect outcomes at the scale of the Interior Columbia River Basin and that aggressive active management could result in short-term fish habitat degradation. Specific to Mid-C steelhead populations in Oregon, Rieman et al. (2000) concluded that only in the Westside Deschutes River population and a few other locations would intensive forest restoration activities be potentially compatible with restoration of aquatic conditions, and only under very specific guidelines. The USFS specifically addressed the issue of fuels treatment as an action contributing to recovery of ESA listed salmonids. They concluded that any evaluation of trade-offs to ESA listed salmonids from fuel treatments will be dependent on local conditions and successful integration of both forest and aquatic system restoration objectives. Site specific multi-scale analyses to evaluate benefits and risks of fuels treatments are necessary to assess potential value or detriment to recovery (Appendix J).

In addition to previously described forest health issues, western juniper has expanded across a large area within the DPS. The estimated acres of juniper forest and savanna in Oregon increased since the 1930's from about 1.5 million acres to 6.5 million acres. The expansion of juniper across the landscape has had an uncertain and unquantified affect on aquatic habitat. Junipers may use more water than other vegetation and can outcompete native vegetation. The overall results are potential reduction in streamflow and altered hydrological processes.

Land use conversion is also an emerging threat. Oregon has had a statewide land use program since 1973. In spite of this effort, areas within the Mid-C DPS, such as the Deschutes subbasin, have experienced a high rate of conversion from resource land to developed land. Deschutes County has been one of the fastest growing counties in the Northwest. The extent to which this conversion has influenced aquatic habitat in the recent past, and the future impact of land use conversion on Mid-C steelhead has not been quantified. Although we did not identify forest

health and land use conversion as primary or secondary threats, there are a number of management actions to address these threats in the management actions section.

We defined seven general types of tributary habitat factors that limit the viability of Oregon's ten steelhead populations in the Mid-C DPS and listed the key contemporary threats to each population at specific life stages.

Degraded floodplain connectivity and function: The loss, impairment or degradation of floodplain connectivity; access to previously available habitats (seasonal wetlands, off-channel habitat, side channels); and a connected and functional hyporheic zone. This factor includes reduced overwinter habitat and channel habitat. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

Degraded channel structure and complexity: The loss, impairment or degradation of channels; a suitable distribution of riffles and functional pools; functional amounts and sizes of large woody debris or other channel structure. Includes reduced summer rearing habitat, degraded spawning habitat, reduced diversity and structure (wood, boulders, etc.), inadequate quantity or depth of pools, loss of side and braided channels. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

Degraded riparian areas and LWD recruitment: The loss, degradation or impairment of riparian conditions important for production of food organisms and organic material, shading, bank stabilizing by roots, nutrient and chemical mediation, control of surface erosion, and production of large-sized woody material. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

Altered hydrologic processes: Changes in the hydrograph that alter the natural pattern of flows over the seasons, causing inadequate flow, scouring flow, or other flow conditions that inhibit the development and survival of salmonids. Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

Degraded water quality: Degraded or impaired water quality due to abnormal temperature, or levels of suspended fine sediment, dissolved oxygen, nutrients from agricultural runoff, heavy metals, pesticides, herbicides and other contaminants (toxics). Life stages affected: egg-to-smolt survival, smolt migration, adult migration, pre-spawning.

Altered sediment routing: Altered sediment routing leading to an overabundance of fine-grained sediments, excess of course-grained sediments, inadequate course-grained sediments and/or contaminated sediment. Includes excessive fine sediment that reduces spawning gravel or increases embeddedness. Life stages affected: egg-to-parr survival.

Impaired fish passage: The total or partial human-caused blockage to previously accessible habitat that eliminates or decreases migration ability or alters the range of conditions under which migration is possible. This may include seasonal or periodic total migration blockage. Includes dams, culverts, seasonal push up dams, unscreened

diversions, and entrainment in irrigation diversions. Life stages affected: smolt migration, adult migration, juvenile upstream migration due to thermal blockage or water availability.

These habitat limiting factors are often interrelated. For example, degraded riparian condition often results in channel straightening, elimination of off-channel habitat, loss of large woody debris, reduced channel roughness, increased water temperatures, and increased sedimentation. Changes in the hydrograph — such as through loss of storage on connected riparian areas, floodplains and uplands — often lead to higher peak flows and lower summer flows, which can impair water conditions and temperatures, or restrict fish movement between habitat reaches.

8.2.1 Fifteenmile Creek Winter Steelhead, Tributary Habitat Limiting Factors

The primary habitat-related limiting factors identified by the recovery planning team for the Fifteenmile Creek steelhead population are low flows, high water temperatures, sedimentation, channel confinement and overall habitat loss due to degraded channel structure and complexity.

Degraded floodplain connectivity and function
By 1910, irrigated farms and pastures occupied the floodplains of Fifteenmile, Eightmile, and Fivemile creeks. Development of irrigated farms and pastures on the floodplain and throughout the valley floor, and associated channel straightening and confinement, reduced available off-channel habitat and floodplain connectivity within the Fifteenmile subbasin. Off-channel habitat and floodplain connectivity declined further with the loss of beaver and from channel straightening and debris removal associated with flood restoration (NPCC 2004a). Stream straightening and debris removal increased stream energy and channel downcutting, causing streams to abandon floodplains and associated off-channels.

Degraded channel structure and complexity
In-channel large wood in the subbasin has declined considerably from historical levels due to channel cleanout and removal of source trees, and resulted in reduced pool frequency and quality. Stream straightening and debris removal led to increased bank erosion and a higher width/depth ratio. Streambank erosion has increased considerably over background levels resulting in direct input of large volumes of sediment and a corresponding increase in width/depth ratio. EDT analysis shows that habitat complexity ─ including habitat diversity, key habitat quantity, and channel stability ─ have been degraded by the straightening and channelization of streams, and other factors. EDT results rated most of the Fifteenmile Creek watershed, except Dry Creek, as a moderate priority for restoring habitat diversity for spawning, active rearing of all age-classes, juvenile migration, winter inactivity, and prespawning holding (NPCC 2004a).

Habitat conditions in the Fifteenmile Creek watershed have begun to improve because of habitat restoration projects conducted since the 1980s. Recent large wood placement and riparian restoration within the Fifteenmile Creek watershed will increase off-channel habitat and floodplain connectivity by encouraging channels to aggrade, but more work is needed. Large wood placement will function to restore processes in the short term, and riparian restoration will help stabilize streambanks and restore ecological processes over the long term. As more large

wood is placed or is naturally recruited, structures that can accommodate movement of large wood will be needed.

Impaired fish passage
While many physical barriers in the Fifteenmile Creek watershed have at least been partially fixed, some remain. Fish screens have been installed on 80 diversions and 5 fish ladders have been installed at diversion structures. Although the fish ladders are no longer barriers to adults, they may still be barriers to upstream juvenile migration (NPCC 2004a). A 1998 ODFW culvert survey identified 11 culverts not meeting fish passage criteria on intermittent streams.

Degraded riparian communities and large wood recruitment
Development of farms, pastures and residential areas in the Fifteenmile subbasin considerably impacted riparian condition and connectivity. Roads were also located in many riparian areas, confining stream channels and eliminating riparian vegetation. Below the forested areas, riparian vegetation and large woody debris was nearly gone well before 1980 due to extensive management associated with residences, agriculture, flood control, livestock grazing, and roads (NPCC 2004a). Riparian impacts were also present in forested areas, but to a lesser extent.

Riparian buffer programs and various restoration projects have been implemented to protect and restore riparian habitat. Timber harvest on national forest land has declined sharply since adoption of the Northwest Forest Plan in 1990. Since 1980, the Forest Service has been working to replace large wood in channels and on floodplains (NPCC 2004a). Roads have largely been eliminated in riparian area on national forest lands, though the middle and lower portions of the watershed still contain extensive riparian roads. In addition, riparian buffers have been established in many parts of the Fifteenmile Creek watershed, areas. Riparian conditions are improving in the lower parts of the watershed through ODFW and USDA programs, and beavers have started re-colonizing the lower watershed. Approximately 126 miles of stream in the watershed has some protection through some form of riparian buffer, either through the NWFP on federal lands, the Forest Practices Act on private forest lands, or programs available to private landowners. Currently, about 30 miles of anadromous habitat lack a forested buffer in the watershed.

Degraded water quality
High water temperatures restrict steelhead production in the Fifteenmile Creek subbasin, particularly in the lower watershed. While spawning occurs in most presettlement spawning areas, temperatures become too high to support one or more life stages. Portions of the middle and lower watershed cannot support any steelhead life stages during late summer due to high water temperatures or dry streams (NPCC 2004a). Water temperatures can also create thermal barriers that prevent fish from moving to cooler reaches. Water temperatures in late summer in lower Fifteenmile Creek, Eightmile Creek, and Fivemile Creek are too high to allow for passage of any life stages. Several reaches in the subbasin are on the 303(d) list for temperature, including Fifteenmile, Ramsey, Dry, Eightmile and Fivemile creeks. Some areas in the watershed exceed the cold-water and rearing standards and are believed to exceed the spawning standard as well, although most of the temperature monitoring has occurred during the summer.

Water quality in the Fifteenmile Creek watershed is also degraded by suspended sediment associated with erosion from land management activities, and possibly chemical contaminants and nutrients. While there is currently not enough data to determine if chemical contaminants and nutrient are a problem, both are likely above presettlement levels because of fertilizer and pesticide use for agriculture.

Altered hydrologic processes

Forest practices, conversion of shrub-steppe habitat to agricultural land, loss of beaver, and road development in the Fifteenmile Creek drainage have affected the subbasin's natural hydrologic regime, resulting in higher peak flows and lower base flows. Peak flows increased by as much as 600% between 1850 and 1950 as very little water was being retained in the soil. On forest lands, runoff increased by 1 to 6% due to forest practices and roads (NPCC 2004a). Below the forest boundary, irrigation withdrawals and the dry climate result in very low flows in most Fifteenmile subbasin streams during the summer. At the time of low summer flow, streamflow has been nearly fully appropriated for irrigation since the early 1900s. The change in base flows causes most lower elevation tributaries to become intermittent during summer months, with flows in some smaller tributaries drying up completely. The shallow water depths can prevent fish passage. The lower portions of Fifteenmile, Eightmile, and Fivemile creeks have been the most impacted by low flows, high water temperatures, and overall habitat loss.

Peak flows have the greatest potential for recovering native vegetation; however, peak flows have partially recovered with the adoption of no-till techniques. Over half of the agricultural land in the watershed has been converted to direct-seed/no-till systems that reduce runoff and erosion by increasing infiltration, leaving 50,000 to 60,000 acres that could be converted (NPCC 2004a).

Altered sediment routing

The geology in the Fifteenmile Creek subbasin lends itself to erosion so any management that disturbs the soil increases fine sediment production. Fine sediment in spawning gravel is a primary concern in the subbasin. Extensive soil loss associated with tilled agriculture has contributed to increased fine sediment in spawning gravel. By 1950, soil loss due to water erosion associated with tilled agriculture in the Fifteenmile Creek watershed was as high as 20 tons per acre per year. Steep slopes and clean tillage were largely responsible for the soil loss (NPCC 2004a). Fifteenmile and Ramsey creeks are on the 303(d) list for sedimentation, and EDT modeling identified sedimentation as one of the key factors inhibiting steelhead production (NPCC 2004a). The adoption of minimum-till and no-till techniques on well over half of the tilled acreage in the watershed has reduced erosion and fine sediment delivery to streams in recent years. Rates of erosion and sediment delivery, however, remain elevated above presettlement rates.

In addition, riparian road densities are highest on private land adjacent to Fivemile, Eightmile, and lower Fifteenmile creeks, with more than a half mile of road per mile of stream within 200 feet of the stream. Forest Service pebble counts have found elevated levels of sand and fine sediment in streams throughout the watershed (NPCC 2004a).

Table 8-13 shows the primary limiting factors identified in the EDT Diagnostic Report for the Fifteenmile Creek winter steelhead population. A summary of the major limiting factors and threats by geographic area is presented in Table 8-14.

Table 8-13. Limiting factors and priorities for protection and restoration as defined by EDT for Fifteenmile Creek Winter Steelhead.

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Fifteenmile Cr-1							●		●			●	●	●	●	●		●
Fifteenmile Cr-2																		
Fifteenmile Cr-3		○	●				●	●	●	●		●	●		●	●		●
Eightmile Cr-1		○	●		●		●	●	●	●			●		●	●		●
Fivemile Cr-1		○	●		●		●	●	●	●			●			●		●
Fivemile Cr-2		○	●				●	●	●	●			●	●		●	●	●
Fivemile Cr-3		◯	●		●		●	●	●	●			●	●		●	●	●
Fivemile Cr-4	○	◯	●				●		●	●					●	●		●
Fivemile Cr SF-1							●		●									●
Fivemile Cr MF-1	○	○	●				●		●									●
Fivemile Cr MF-2											●							
Fivemile Cr MF-3			●				●		●									
Eightmile Cr-2		○	●		●		●	●	●	●			●	●	●	●		●
Eightmile Cr-3		○	●		●		●	●	●	●			●		●	●		●
Eightmile Cr-4		○	●				●	●	●	●			●		●	●		●
Eightmile Cr-5		○	●		●		●	●	●	●			●		●	●		●
Eightmile Cr-6		◯	●		●		●	●	●	●			●		●	●		●
Eightmile Cr-7	○	○	●				●	●	●	●						●		●
Eightmile Cr-8	◯	◯	●				●	●	●						●			●
Eightmile Cr-9	○		●				●		●						●			●
Eightmile Cr-10	◯	○	●				●		●						●			●
Eightmile Cr-11																		
Eightmile Cr-12			●				●		●						●			●
Eightmile Cr-13		○									●							
Eightmile Cr-14							●		●						●			●
Fifteenmile Cr-4		○	●		●		●	●	●	●		●	●		●	●		●
Fifteenmile Cr-5		◯	●		●		●	●	●	●		●	●		●	●		●
Fifteenmile Cr-6		○	●		●		●	●	●	●		●	●		●	●		●
Dry Cr-1		○	●		●		●	●	●	●			●		●	●		●
Dry Cr-2		○	●		●		●	●	●				●	●		●		●
Fifteenmile Cr-7		○	●		●		●	●	●	●			●		●	●		●
Fifteenmile Cr-8	○	○	●		●		●	●	●	●			●			●		●
Ramsey Cr-1		○	●				●	●	●	●			●		●	●		●
Ramsey Cr-2	○		●				●	●	●	●					●	●		●
Ramsey Cr-3	○	○	●				●		●						●			●
Ramsey Cr-4	◯	○					●		●									
Ramsey Cr-5											●							
Ramsey Cr-6			●				●		●						●			●
Ramsey Cr-7											●							
Ramsey Cr-8			●				●		●						●			●
Fifteenmile Cr-9	○	◯	●		●		●	●	●	●					●	●		●
Fifteenmile Cr-10	○		●				●		●						●	●		●
Fifteenmile Cr-11	○	○	●				●		●						●	●		●
Fifteenmile Cr-12	◯	○																●
Fifteenmile Cr-13	◯	○							●									●
Cedar Cr	○		●				●		●									●
Fifteenmile Cr-14	◯								●									●
Fifteenmile Cr-15	○																	●
Fifteenmile Cr-16	○		●						●									●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

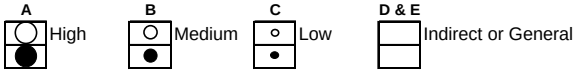


Table 8-14. Habitat limiting factors summary for the Fifteenmile Creek steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
FIFTEENMILE CREEK POPULATION					
Fifteenmile Creek Population	Altered hydrology (low flows); Water quality (temps); altered sediment routing; degraded floodplain; degraded channel structure (channel confinement, overall habitat loss), degraded riparian condition	MaSAs and MiSAs	Productivity, abundance, spatial structure, diversity	Roads, residential development, agricultural practices and forest practices, irrigation diversions, and loss of beaver	All life stages
Upper Fifteenmile Creek MaSA	Degraded floodplain and channel structure (shorter/steeper, diversity, stability); degraded riparian community; altered sediment routing; altered hydrology; degraded water quality (temp); blocked or impaired fish passage	Fifteenmile [F, CS, R, T (RM 0-40), H (mouth to Pine Cr.), S (RM 0-52.7)]; Dry Creek [F, CS, T (RM 0-16.6),H]; Ramsey Creek [F, CS, BP (on Mt. Hood NF block 2,357 feet of habitat), T (RM 0-5.4), H, S (RM 0-13.2)]; Long Hollow, Douglas Hollow, Standard Hollow, Mays Canyon [IP (culverts)]	Productivity, abundance, spatial structure and diversity	Roads, residential development, agricultural and forest practices, irrigation diversions, and loss of beaver	All life stages are affected.
Eightmile Creek MaSA	Water quality (temp); altered hydrology; degraded riparian communities; altered sediment routing; impaired fish passage	Eightmile Cr. [F, CS, IP (culverts at campground and RM 10), T (RM 0-22), R, H, S (RM 0-34.5)]; Japanese Hollow [IP]	Productivity, abundance, spatial structure and diversity	Roads, residential development, agricultural and forest practices, irrigation diversions, and loss of beaver	All life stages are affected.
Fivemile Creek MaSA	Water quality (temp); altered hydrology; altered sediment routing; degraded riparian communities; impaired fish passage	Fivemile Creek [F, CS, R, T, H, S]; Middle Fork Fivemile Cr [F, CS, BP (culvert), IP,T, R, H]	Productivity, abundance, spatial structure and diversity	Road building, legacy forest roads, residential development, agricultural and forest practices, irrigation diversions, and loss of beaver	All life stages are affected.

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F), degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), high water temperatures (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.2 Deschutes River Eastside Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for the Deschutes Eastside steelhead population are degraded riparian condition, low flows, high water temperatures, degraded channel structure/complexity and floodplain connectivity, impaired fish passage.

Degraded floodplain connectivity and function
Off-channel habitats, including wet meadows, oxbows and backwater areas have been reduced by floodplain degradation and loss of beaver. These areas provided juvenile rearing habitat and helped moderate streamflows and water temperature alterations.

Degraded channel structure and complexity
Habitat complexity is generally impaired in most stream reaches used by the Deschutes Eastside steelhead population. Large wood and pool habitat is lacking, thus limiting salmonid production. During summer low flows, a small number of pools with little cover provide the only available habitat for juveniles and adults. The lack of pool habitat confines large numbers of fish to small areas with very little cover, exposing them to potential predation (NPCC 2004b).

EDT results identified reduced habitat diversity as a major factor limiting steelhead in the Buck Hollow, Bakeoven, and Trout creek systems. Reduced habitat diversity ranked as extreme or high for several reaches. Other major limiting for these streams include the loss of instream habitat complexity and pool habitat for rearing, reduced spawning habitat diversity and high temperatures for egg incubation and 0-age rearing, and low flow for 0- to 2-age rearing (NPCC 2004b). EDT results also identified habitat diversity for spawning and rearing and channel stability as major habitat constraints in the smaller tributaries (NPCC 2004b).

Degraded riparian communities and large wood recruitment
Streams on the lower eastside of the Deschutes have been considerably impacted by beaver harvest, irrigation, roads, and cattle grazing; particularly since soils in many eastside stream systems are not very permeable and are prone to landslides. With the loss of riparian vegetation, streams began eroding vertically and horizontally during storm events. Roads were located in many of the riparian areas within the subbasin (NPCC 2004b). Channel downcutting contributed to lowering the water table, which exacerbated the loss of riparian vegetation (NPCC 2004b). Riparian vegetation is recovering in many areas because the impacts associated with grazing have been reduced through improved livestock management practices, including early season use, better livestock distribution, shorter use duration, lower intensity of use, and installation of livestock exclosures (NPCC 2004b). With the recovery of riparian vegetation, beavers have started recolonizing the eastside tributaries (NPCC 2004b).

Degraded water quality
Water temperatures in the eastside tributaries naturally rise more quickly and reach higher levels than westside tributaries because of warmer air temperatures and more arid conditions (NPCC 2004b). Temperatures have increased because of land use practices, and now typically exceed State water quality criteria for salmonid rearing during summer months. Buck Hollow Creek (RM 0-37.7) is on the 303(d) list for temperature and Trout Creek (RM 0-50.7) and tributaries Tenmile, Auger, Big Log, Bull Cartwright, Dick, Dutchman and Potlid creeks are on the 303(d) list for temperature and sedimentation. In Buck Hollow Creek, summer water temperatures often rise above 75° F, except in areas of cool water refuge where seeps and springs enter the channel, or where widely scattered deep pools are recharged with cool subsurface flow. In Trout Creek, water temperatures usually surpass recommended levels by late May and can remain high through October (NPCC 2004b). Bakeoven Creek also experiences high water temperatures and other water quality problems, including turbidity, low dissolved oxygen and nutrients.

Altered hydrologic processes
The eastside streams are very flashy due to their high average slope, high drainage densities, and occasional severe thunderstorms (NPCC 2004b). The uplands are generally degraded by grazing and agriculture; reducing the soil's ability to collect and store moisture, contributing to the flashy nature of the streams. Approximately 370,000 acres of contiguous interior grassland that existed in the upper Bakeoven, Buck Hollow, and Antelope watersheds has been lost to encroachment by other habitat types and land use (NPCC 2004b). There has also been an increase in the drainage network due to roads. Roads and ditches increase runoff by intercepting ground water from cut slopes and collecting precipitation and routing it directly to stream channels.

Combined upland and riparian degradation has resulted in an altered flow regime with higher peak flows and lower base flows. In places where juniper encroachment has resulted in woodland stands, hydrologic processes have likely been altered. The Natural Resource Conservation Service estimates that current peak flows in some segments of the Trout Creek system are two to three times greater than under pre-settlement conditions (Jefferson County SWCD 1996). Some streams are intermittent in summer months. EDT results identified low flows for 0- to 1-age rearing as a major habitat constraint in the smaller tributaries (NPCC 2004b).

Altered sediment routing
Substrate has been degraded by fine sediment deposition from tilling practices associate with dry cropland farming. However, no-till techniques, which have greatly reduced erosion and sediment delivery to substrate, are being adopted (NPCC 2004b). EDT results identified sediment during egg incubation as a major habitat constraint in the smaller tributaries (NPCC 2004b). Buck Hollow is a gravel-rich system, but fine sediment levels are elevated.

Blocked or impaired fish passage
A road crossing on Stag Canyon impairs fish passage. On the Trout Creek system, numerous push-up dams block fish passage during the irrigation season, including on Trout Creek between Little Trout Creek and Board Hollow Creek, on Antelope Creek between the mouth and Ward Creek, and on Clover Creek. Most irrigation diversions have been screened or replaced with infiltration galleries. Road culverts affect fish passage. Mud Springs Creek contains a high gradient concrete box culvert in section 15 that is a barrier, and a culvert just upstream of Gateway that is a barrier. Relocation of Hay Creek has created a barrier cascade in the SW corner of section 17 near the mouth of Hay Creek. Other barriers in Hay Creek include storage reservoirs (NPCC 2004b).

Table 8-15 shows limiting factors and priorities identified by EDT Diagnostic Reports for the Deschutes Eastside steelhead population. A summary of major limiting factors and threats by geographic area is presented in Table 8-16.

Table 8-15. Limiting factors and priorities for restoration as defined by EDT for Deschutes River Eastside steelhead population.

Geographic area priority			Attribute class priority for restoration																	
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
L Deschutes MS-1					●				●					●				●
L Deschutes MS-2	○				●				●					●				●
Fall Canyon							●		●									●
L Deschutes MS-3					●				●					●				
L Deschutes MS-4	○				●		●		●					●				
Macks Canyon			●				●		●									●
L Deschutes MS-5		○			●		●		●					●	●	●		
Ferry Canyon							●		●						●			●
L Deschutes MS-6		◯			●		●		●					●	●			
Jones Canyon			●				●		●									●
L Deschutes MS-7		○			●		●		●					●	●			
Oak Canyon			●				●		●									●
L Deschutes MS-8		◯			●		●		●					●	●			
Buck Hollow Cr-1	○	◯	●				●		●					●	●	●		●
Finnegan Canyon			●				●		●						●			●
Buck Hollow Cr-2		○	●				●		●					●	●	●		●
Hauser Canyon							●		●									●
Buck Hollow Cr-3	○	◯	●				●		●				●	●		●		●
Macken Canyon							●		●									
Buck Hollow Cr-4		○	●				●		●					●		●		●
Thorn Hollow	○	◯	●				●		●					●		●		●
Buck Hollow Cr-5							●		●					●		●		●
L Deschutes MS-9					●		●		●									●
L Deschutes MS-10																		
L Deschutes MS-11					●				●					●				●
White R MS-1							●		●					●				●
L Deschutes MS-12	○	○	●		●		●		●					●				
Bakeoven Cr-1	○	○	●				●		●					●		●		●
Trail Hollow Cr			●				●		●									●
Bakeoven Cr-2		○	●				●		●					●		●		●
Booten Cr			●				●		●							●		●
Bakeoven Cr-3		○	●				●		●					●		●		●
Robin Cr			●				●		●									●
Bakeoven Cr-4		◯	●				●		●				●	●		●		●
Deep Cr-1 (Bakeoven)		◯	●				●		●				●	●		●		●
Cottonwood Cr-1		○	●				●		●				●	●		●		●
Ochoco Gulch Cr							●		●							●		●
Cottonwood Cr-2			●				●		●					●		●		●
Deep Cr-2 (Bakeoven)		◯	●				●		●				●	●		●		●
Maupin Trail Canyon			●				●		●				●	●		●		
Deep Cr-3 (Bakeoven)		○	●				●		●				●	●		●		●
Bakeoven Cr-5			●				●		●					●		●		●
L Deschutes MS-13	○	○	●		●		●		●	●			●	●		●		
Stag Canyon			●				●		●				●	●		●		
L Deschutes MS-14	○	○	●		●		●		●					●				●
Wapinitia Cr-1							●		●					●	●			●
L Deschutes MS-15	◯	○			●		●		●					●				
Nena Cr-1			●				●		●					●		●		●
L Deschutes MS-16	◯	◯					●		●									
Eagle Cr			●				●		●					●		●		●
L Deschutes MS-17	◯	◯	●		●		●		●					●				
Skookum Cr							●		●							●		●
L Deschutes MS-18	○	○	●		●		●		●					●				
Warm Springs MS-1					●		●		●				●					
L Deschutes MS-19	◯	○			●		●		●					●				
Trout Cr-1			●				●		●					●		●		●

Table 8-15 cont.

Geographic area priority			Attribute class priority for restoration																	
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Trout Cr-7		A	●				●		●				●	●	●	●		●
Trout Cr-8		A	●				●		●				●	●	●	●		●
Trout Cr-9		B	●				●		●				●	●	●	●		●
Wapinitia Cr-1	B	A	●				●		●					●	●	●		●
Wapinitia Cr-2		B	●				●		●				●	●	●	●		●
Ward Cr-1	B	B	●				●		●					●		●		
White R MS-1					●		●		●					●		●		●
Amity Cr		B	●				●		●				●	●	●	●		●
Antelope Cr-1		B	●				●		●				●	●		●		●
Antelope Cr-2		B	●				●		●				●	●	●	●		
Auger Cr	B		●				●		●					●		●		
Bakeoven Cr-1	B		●				●		●					●		●		●
Bakeoven Cr-2		B	●				●		●					●		●		●
Bakeoven Cr-3		B	●				●		●					●		●		●
Bakeoven Cr-4		A	●				●		●				●	●		●		●
Beaver Cr (Trout)	B		●				●		●					●		●		
Big Log Cr-1	B		●				●		●					●		●		
Big Log Cr-2	B		●				●		●					●		●		●
Big Whetstone Cr			●				●		●					●		●		
Board Hollow Cr	B		●				●		●					●		●		●
Buck Hollow Cr-1	B	A	●				●		●					●	●	●		●
Buck Hollow Cr-2		B	●				●		●					●	●	●		●
Buck Hollow Cr-3	B	A	●				●		●				●	●		●		●
Buck Hollow Cr-4	B	B	●				●		●					●		●		●
Cartwright Cr	B		●				●		●					●		●		
Clover Cr	B		●				●		●					●		●		
Cottonwood Cr-1		B	●				●		●				●	●		●		●
Cottonwood Cr-2			●				●		●				●	●		●		●
Deep Cr-3 (Bakeoven)	B	B	●				●		●					●		●		●
Dutchman Cr	B		●				●		●					●		●		
Eagle Cr		B	●				●		●				●	●		●		●
Foley Cr-1	B		●				●		●					●		●		
Foley Cr-2	B	B	●				●		●					●		●		
Hay Cr-1			●				●		●	●			●	●		●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

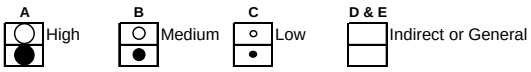


Table 8-16. Habitat limiting factors summary for the Deschutes River Eastside steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Potential Causes/Threats	Life Stages Affected
DESCHUTES EASTSIDE POPULATION					
Deschutes River Eastside Population	Degraded floodplain and channel structure (complexity, deep pools, diversity); degraded riparian communities; water quality (temp, chemical contaminants and nutrients); altered hydrology (higher peak, lower low flows); altered sediment routing	MaSAs and MiSAs	Productivity, abundance, spatial structure and diversity	Livestock grazing, roads, residences, agricultural practices that simplify habitat, irrigation withdrawals, dams and other barriers	All life stages
Buck Hollow MaSA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology, degraded water quality (temp); altered sediment routing	Buck Hollow [F, CS (mouth to Thorn Hollow), T (RM 0-37.7); H; S]; Thorn Hollow Cr. [R, F, CS (mouth to spring in section 23), S]	Productivity, abundance, spatial structure and diversity	Livestock grazing, upland agricultural practices	All life stages are affected.
Bakeoven MaSA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp); altered sediment routing; impaired fish passage	Bakeoven [F, CS, T, H, S (mouth to Deep Cr.), IP (road crossing at Stag Canyon)]; Deep Cr. [F, CS (especially mouth to Cottonwood Cr)]; Cottonwood Cr. [F, CS (mouth to Ochoco Cr)]	Productivity, abundance, spatial structure and diversity	Livestock grazing, upland agricultural practices, irrigation, roads	All life stages are affected.
Ward/ Antelope/Cold MaSA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; blocked and impaired fish passage	Most drainages [F, CS, H]; Antelope Cr. [BP (push-up dams]	Productivity, abundance, spatial structure and diversity	Irrigation withdrawals, agricultural practices	All life stages are affected.
Lower Trout Cr. MaSA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp); altered sediment routing; blocked and impaired fish passage	Trout Cr. [H (especially below Willowdale), T (RM 0-50.7), F, CS, R, S, PB (Mud Springs Cr., Hay Cr.)]; Tenmile Cr. [T (RM 0-5.9)]; Mud Cr. [IP (culvert in section 15 and just above Gateway)]; Hay Cr. [IP (cascade near mouth, storage reservoirs, diversions)]	Productivity, abundance, spatial structure and diversity	Agricultural practices, channel simplification following flood, roads, irrigation storage reservoirs and diversions, livestock grazing	All life stages are affected.
Upper Trout Cr. MaSA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp); altered sediment routing; blocked and impaired fish passage	Trout Cr. [F, CS (mouth to 4,800-ft level, especially below NF boundary), R, T, S (RM 0-50.7), H (especially below Ashwood), IP (Little Trout to Board Hollow)]; Big Log Cr. [T and S (RM 0-5.5)]; Cartwright Cr. [T and S (RM 0-4.3)]; Dick Cr. [T and S (RM 0-2.2)]; Dutchman Cr. [T and S (RM 0-4.8)]; Potlid Cr. [T and S (RM 0-5.2)]; Bull Cr. [T and S (RM 0-1.8)]; all systems [F, CS]; Clover Cr. [IP].	Productivity, abundance, spatial structure and diversity	Livestock grazing, agriculture practices, building of flood control berms, channel straightening, roads	All life stages are affected.

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F), degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.3 Deschutes River Westside Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the Recovery Planning Team for the Deschutes Westside steelhead population are degraded channel structure and complexity, altered sediment routing, high water temperature, low flows and lack of fish passage over Pelton-Round Butte Complex.

Degraded riparian communities and large wood recruitment
The Shitike Creek and Warm Springs River systems have experienced a slight to moderate loss of riparian vegetation and vegetative diversity due to grazing, roads and other land use practices. Habitat is primarily degraded in the lower reaches, with upper reaches in good to excellent condition (NPCC 2004b). The lower four miles of Shitike Creek have experienced substantial loss of riparian vegetation. The cottonwood gallery forest is now a fraction of its former size and contributes a smaller amount of large wood to the stream channel. Roads located in many riparian areas within the subbasin have played a major role in degrading riparian habitat in the Shitike Creek and Warm Springs River systems (NPCC 2004b). Riparian fencing in some areas of the Warm Springs River system has allowed riparian vegetation to become established that has stabilized stream banks (NPCC 2004b).

Riparian conditions along upper and lower Whychus Creek are generally good. Many sections of lower Whychus Creek have a broad riparian area comprised of floodplains, willow stands and cottonwood bottom lands. Riparian vegetation along sections of the creek's middle reach has been damaged by past grazing, channel alterations and development (NPCC 2004b).

Degraded floodplain connectivity and function
Off-channel habitats provide critical steelhead habitat. In 1995, about 68% of all steelhead spawning in the Deschutes River from the Reregulating Dam to Trout Creek occurred in side channels between islands and channel margins, despite the fact that such channels comprise less than 10% of the channel length in the reach (Zimmerman and Ratliff 2003). In tributary reaches, including the Warm Springs drainage and many small tributaries in the area, loss of connectivity with the floodplain has reduced groundwater discharge, further exacerbating problems of low flow and high water temperature. This is especially true for the lower four miles of Shitike Creek and segments of Beaver Creek where Hwy 26 has reduced floodplain connectivity.

Degraded channel structure and complexity
The results of EDT analysis identified lack of habitat diversity and complexity as major limiting factors for the Deschutes River above Trout Creek, and for several reaches on Shitike Creek and the Warm Springs River system. Habitat degradation on the stretch of the Deschutes River above the mouth of Trout Creek results primarily from recreational impacts on riparian vegetation on the east side of the river and from grazing impacts on the west side of the river. On lower Shitike Creek and the Warm Springs River, channel simplification and land use practices have accentuated flashy flows that scour the channel and reduce habitat complexity (NPCC 2004b). Some instream habitat projects have been implemented on the Warm Springs River and have increased habitat complexity (NPCC 2004b). Channelization and loss of large wood along the lower four miles of Shitike Creek have reduced channel and fish habitat heterogeneity (e.g. side channels, substrate diversity, etc.). Loss of floodplain connectivity has

resulted in increased water temperatures and the loss of off-channel juvenile rearing habitat and winter high flow refugia. EDT results identified channel instability as a major limiting factor for the Shitike and Warm Springs systems (NPCC 2004b). In the Whychus Creek drainage, channel simplification has reduced channel complexity and stability from RM 24.7 to the National Grassland Boundary (RM 5), resulting in a loss of sinuosity and stream length (NPCC 2004b).

Degraded water quality

The lower Deschutes River and several westside tributary reaches are included on the 2002 ODEQ 303(d) list of water quality limited streams (NPCC 2004b). The lower Deschutes River exceeds temperature criteria for salmonid rearing from White River to Pelton Dam. In addition, water temperatures in lower reaches of Warm Springs River and Shitike Creek can exceed 70°F from mid to late summer. EDT results identified water temperature during incubation and juvenile rearing as a major limiting factor in lower Shitike Creek, Beaver Creek, and several other reaches (NPCC 2004b). Suspended sediment further reduces water quality in smaller tributaries to the Deschutes River and in Quartz and Coyote creeks in the Warm Springs River system. Whychus Creek is also included on the 2002 ODEQ 303(d) list for exceeding water temperature criterion for salmonid spawning during summer months (NPCC 2004b).

Information regarding chemical contaminants and nutrients in streams is lacking for this area. It is likely that levels of both are above pre-settlement levels because of fertilizer and pesticide use for agriculture. Irrigation return flows to the Deschutes River and its tributaries may pose water quality problems (NPCC 2004b). Contaminants from municipal waste spill/discharge into Shitike Creek and from water lagoons and golf course at the resort on the mainstem Warm Springs River also degraded water quality.

Altered hydrologic processes

Lands in watersheds that support the Deschutes River Westside steelhead population have generally been degraded through grazing, agriculture, forest practices, and roads, and are not able to capture and slowly release precipitation as efficiently as they did historically. Headwater channel scour has reduced water storage and lowered the water table (NPCC 2004b). This is especially true for Coyote, Quartz, Tenino, Skookum, Eagle, and Nena Creeks. It is also the case on upper Beaver Creek where the creek has been channelized along Hwy 26. Flows, which are dominated by snowmelt, peak in spring and taper off through the summer to base levels in August or September. Small tributary flows are often intermittent, limiting habitat availability in the summer. EDT results identified reduced streamflows as a major limiting factor in this area.

Altered sediment routing

Fine sediment levels in spawning substrate are a concern in Shitike and Warm Springs systems and small tributaries to the Deschutes River. Several drainages, including Quartz and Coyote creeks in the Warm Springs system, contain highly erosive soils that have become more unstable due to extensive grazing, construction of logging roads, and conversion of land for tilled agriculture (NPCC 2004b). Excessive sediment loads also occur occasionally in the Warm Springs River, primarily due to runoff from lower tributaries, including Coyote and Quartz creeks in the Beaver Creek drainage, and from Charlie Canyon. Lower Whychus Creek also displays a high percentage of fine sediment associated with unstable streambanks and livestock grazing (NPCC 2004b).

The small tributaries to the Deschutes River have become incised and lost some of the steelhead spawning gravel that was historically abundant. In-channel large wood, which has decreased the ability of streams to sort and store spawning gravels, has also been reduced throughout the area (NPCC 2004b). Increased fine sediment in small tributaries results from cropland and rangeland runoff. Substrates contained less fine sediment before European settlement due to stable vegetation conditions (NPCC 2004b).

Impaired fish passage

The Pelton-Round Butte Complex on the Deschutes River at RM 100 blocks fish passage to and from historical habitats in the Metolius River, Whychus Creek and other previously accessible habitats above the complex. Fish passage facilities were constructed with the dams, but attempts to pass juveniles out of the system failed. Currently efforts are underway to restore passage as part of the FERC relicensing process (NPCC 2004b). The new downstream fish passage structure is scheduled to be functioning by 2010. Details of the proposed reintroduction are presented in the tributary hydro actions in Section 9.

Adult steelhead are also affected by structural barriers, such as culverts, irrigation diversions, roads and railroad crossings that block upstream passage. Juvenile rearing is greatly affected by all of the passage barriers.

Table 8-17 shows limiting factors and priorities identified in the EDT Diagnostic Report for the Deschutes Westside steelhead population. A summary of the major limiting factors and threats by geographic area is presented in Table 8-18.

Table 8-17. Limiting factors and priorities for restoration as defined by EDT for Deschutes River Westside steelhead population.

Geographic area priority			Attribute class priority for restoration																	
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
L Deschutes MS-1									●					●				
L Deschutes MS-2					●				●					●				●
L Deschutes MS-3									●					●				
L Deschutes MS-4					●				●					●				
Macks Canyon							●		●									●
L Deschutes MS-5					●				●					●				
Ferry Canyon							●		●						●			●
L Deschutes MS-6					●				●					●				
Jones Canyon			●				●		●									●
L Deschutes MS-7					●				●					●				
Oak Canyon			●				●		●									●
L Deschutes MS-8					●				●					●				
Buck Hollow Cr-1			●				●		●					●				●
L Deschutes MS-9					●		●		●									●
L Deschutes MS-10																		
L Deschutes MS-11					●		●		●					●				●
White R MS-1					●		●		●					●		●		●
L Deschutes MS-12					●				●					●				
Bakeoven Cr-1							●		●					●				●
L Deschutes MS-13					●		●		●				●	●				
Stag Canyon			●				●		●					●		●		
L Deschutes MS-14			●		●		●		●					●				●
Wapinitia Cr-1		◯	●				●		●					●	●	●		●
Paquet Gulch-1							●		●							●		●
Wapinitia Cr-2		○	●				●		●				●	●	●	●		●
L Deschutes MS-15					●				●									
Nena Cr-1		○	●				●		●				●	●		●		●
L Deschutes MS-16							●		●									
Eagle Cr		○	●				●		●				●	●		●		●
L Deschutes MS-17		○			●		●		●					●				
Skookum Cr		○	●				●		●				●	●		●		●
L Deschutes MS-18		○			●				●									
Warm Springs MS-1		◯			●		●		●									
Warm Springs MS-2		○									●							
Warm Springs MS-3		◯			●		●		●				●	●				
Beaver Cr-1 (WS)	◯	◯	●		●		●		●					●	●	●		●
Beaver Cr-2 (WS)	◯	○					●		●							●		
Beaver Cr-3 (WS)	◯	○					●		●						●	●		●
Beaver Cr-4 (WS)	◯						●									●		●
Beaver Cr-5 (WS)	○						●									●		●
Warm Springs MS-4		○			●		●		●									●
Mill Cr-1 (WS)					●		●		●									●
Boulder Cr (WS)	◯	◯	●				●		●							●		●
Mill Cr-2 (WS)	○	○	●		●		●		●					●	●			●
Warm Springs MS-5	○	○							●									
Badger Cr (WS)	○	◯					●		●							●		●
Warm Springs MS-6	○	○					●		●						●			●
Warm Springs MS-7	◯	◯					●		●						●			
Warm Springs MS-8	◯	○					●		●						●			
Bunchgrass Cr									●									●
Warm Springs MS-9	◯	◯					●		●						●			
L Deschutes MS-19					●				●									
Trout Cr-1							●		●							●		●
Trout Cr-2							●		●					●		●		●
L Deschutes MS-20	○	◯			●		●		●					●				
Shitike Cr-1	◯	◯	●		●		●	●	●						●	●		●

Table 8-18. Habitat limiting factors summary for the Deschutes River Westside steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Potential Causes/Threats	Life Stages Affected
DESCHUTES WESTSIDE POPULATION					
Deschutes River Westside Population	Degraded riparian communities; degraded floodplain and channel structure (complexity, side-channel habitat, diversity); water quality (temp); altered hydrology (low flow); altered sediment routing; blocked and impaired fish passage	MaSAs and MiSAs	Abundance, productivity, spatial structure, diversity	Primarily livestock grazing, roads, residential development and agricultural practices that simplify habitat, irrigation withdrawals, forest practices, dams and other barriers	All life stages
Lower Warm Springs MaSA	Degraded floodplain and channel structure (complexity, loss of LWD); degraded riparian communities; degraded water quality (temp); altered hydrology; altered sediment routing	Beaver Creek [R, F, CS, T, S (mouth to Wilson Cr.)]; Warm Springs R. [(F, CS and R in Ka-Nee-Ta resort area), S, R (mouth to Schoolie Cr.)]; Quartz and Coyote creeks [F, CS, S]	Productivity, abundance, spatial structure and diversity	Confinement and runoff from Hwy. 26, livestock grazing, bank armoring and confinement in Ka-Nee-Ta area	All life stages
Middle Warms Springs MaSA	Degraded riparian communities; degraded floodplain and channel structure; altered sediment routing	Badger Creek	Productivity, abundance, spatial structure and diversity	Primarily livestock grazing, roads, and agriculture practices	All life stages
Upper Warm Springs MaSA	Degraded channel structure; water quality (temp)	SF Warm Springs and Upper Warm Springs Rs	Productivity, abundance, spatial structure and diversity	Loss of LWD	All life stages
Mill Creek MaSA	Degraded floodplain and channel structure (channelization, complexity)	Mill Cr. [mouth to Old Mill Camp]	Productivity, abundance, spatial structure and diversity	Channelization	All life stages
Shitike Creek MaSA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp, pollutants); altered sediment routing	Shitike Cr. [F, CS, R (mouth to upper road crossing, City of Warm Springs, near Hwy. 26); WQ (Warm Springs mill site and sewage lagoons)]	Productivity, abundance, spatial structure and diversity	Livestock grazing, riparian degradation and confinement through Warm Springs, Hwy. 26, Warm Springs mill site and sewage lagoons, channelization	All life stages

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F), degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), high water temperatures (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.4 Crooked River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified for the Crooked River steelhead population are degraded channel structure and complexity and floodplain connectivity, degraded riparian condition, high water temperature, low flows and lack of fish passage over Pelton-Round Butte Complex (ODFW 1996).

The Crooked River and tributaries were historically inhabited by Mid Columbia summer steelhead. They were extirpated in the upper Ochoco Creek watershed in 1921 with the construction of Ochoco Dam approximately five miles east of Prineville. Steelhead use in the upper mainstem Crooked River including the North and South forks and Beaver and Bear creeks was terminated with the completion of Bowman Dam at Rm 70 in 1961. Limiting factors are similar for habitats upstream and downstream of the two dams. However, only the lower Crooked River watershed below the dams is identified by the Upper Deschutes Subbasin Plan amendment (ODFW 2003) for reintroduction of the species. Discussion of habitat limiting factors in the Crooked River watershed will focus on the reintroduction area followed by a section describing conditions in the upper watershed above Ochoco and Bowman dams.

Degraded riparian communities and large wood recruitment
Riparian vegetation condition in the lower Crooked River watershed is largely a function of geomorphology and land use practices. Two separate reaches of the mainstem flow through steep narrow basalt canyons and are managed by the Bureau of Land Management as Wild and Scenic Rivers. These reaches extend from the head of Lake Billy Chinook at Rm 6 to the Highway 97 crossing at Rm 17 and from Rm 62 upstream from Prineville to Bowman Dam at Rm 70. Riparian communities in these reaches are in excellent condition resulting in stable channel conditions and reduced sediment inputs. However, limited numbers of large riparian trees, lack of wood recruitment from portions of the watershed above Ochoco and Bowman Dams and periodic scouring high flow events result in these reaches lacking in large wood.

Riparian condition in the mainstem between the two Wild and Scenic reaches is extremely degraded. Past grazing and agricultural practices contributed to almost complete removal of native vegetation resulting in bank instability, minimal canopy cover and high sediment loads. Restoration efforts have had limited success due to the erosive soils, lack of vegetation, incised channel and altered hydrograph. Large wood is absent in this reach.

Ochoco Creek below Ochoco Dam is characterized by largely degraded riparian conditions resulting from livestock and agricultural practices as well as development in and around Prineville. Scattered remnant willows and cottonwoods are present but the riparian community is dominated by reed canary grass. Limited overstory canopy is present in the section of the creek that flows through Prineville. Large wood is absent. Riparian conditions in lower McKay Creek are similar to Ochoco Creek. The upper McKay watershed is on USDA Ochoco National Forest ownership. Riparian conditions are significantly improved from that of the lower watershed. Vegetation consists of both conifers and woody species. Full site potential is not realized due to livestock grazing and damage resulting from unauthorized off highway vehicle use.

Degraded floodplain connectivity and function
Floodplain interaction in the lower Crooked River was important for dissipating energy during high flow events, providing off channel refugia for juvenile salmonids and storing water for late season release. Floodplain connectivity and function is variable within the Crooked River steelhead reintroduction area. Generally, in the Wild and Scenic reaches of the mainstem and upper McKay Creek connectivity is intact. However, the middle section of the mainstem, Ochoco Creek and lower McKay Creek have limited connectivity to the floodplain. In particular, the reach of the Crooked River from Lone Pine to Prineville (Rm 31 to Rm 51) has a deeply incised channel and extremely poor floodplain connectivity resulting in chronic bank erosion that has hampered restoration efforts.

Degraded channel structure and complexity
Diverse habitats including pools and structures providing cover increase the production capacity of a stream through increased holding areas for migrating adults and particularly for juvenile steelhead rearing. The entire section of the Crooked River watershed in the steelhead reintroduction area was channelized following the 1964 floods excluding the two canyon reaches of the mainstem and the upper section of McKay Creek. Channelization resulted in severe reduction in channel complexity and width/depth and pool/riffle indices.

Degraded water quality
Water quality degradation in the Crooked River is largely from nonpoint pollution sources including livestock grazing, timber harvest, and agricultural and stormwater runoff. Primary water quality parameters limiting steelhead production are temperature, dissolved oxygen and turbidity. The Crooked River is on the Oregon Department of Environmental Quality's 303d list for not meeting water quality standards for temperature, turbidity and total dissolved gas. In particular, the Crooked River mainstem from the Highway 97 crossing (Rm 17) to the Feed Canal (Rm 51) suffers from chronically high summer temperatures often in excess of 80F. Partially treated wastewater discharged into the river near Prineville during the winter months also impairs water quality.

The hypolimnotic release of water from Bowman Dam results in cool water (52F) discharged into the Crooked River. This results in favorable summer conditions supporting a very robust redband trout population and popular tailrace fishery. Conversely, flows released from the dam in excess of 2000 cfs result in nitrogen supersaturation and dependent upon length of exposure can result in varying degrees of gas bubble disease.

Altered hydrologic processes
The natural hydrograph was largely driven by climactic patterns of the Blue Mountain physiographic province characterized by hot arid summers and cold winters. The majority of annual precipitation occurred as snowfall. Annual streamflow was determined largely by snowpack. This resulted in low to moderate year around base flow with annual spring runoff events.

The hydrology of the lower Crooked River steelhead reintroduction area has been significantly altered by construction of Ochoco and Bowman dams and management of water released from Prineville and Ochoco reservoirs, irrigation practices and removal of beaver. Reservoir

management has the greatest influence on flows in the mainstem Crooked River and Ochoco Creek. Releases of water for irrigation delivery result in flows (250 cfs – Crooked R., 20 cfs - Ochoco Cr.) exceeding natural levels from April through October in the reaches upstream of the major points of diversion: Rm 51 to Rm 70 on the Crooked and Rm 3 to Rm 10 on Ochoco Creek. At the close of irrigation season in October, water is stored in the two reservoirs and releases are reduced to 50-75 cfs in the Crooked River (legally protected flows in the non irrigation period are 10 cfs) and 5-10 cfs in Ochoco Creek. This pattern is occasionally punctuated by spring high flow events when the respective reservoirs fill and inflow is discharged downstream. This flow management has generally resulted in robust populations of redband trout in the tailrace reaches of both the Crooked River and Ochoco Creek Below the major points of diversion streamflows are critically low, particularly in the Crooked River from Rm 14 to Rm 51. Low summer flows and high temperatures (exceeding 80F) limit trout production in this reach. Below the Highway 97 crossing on the Crooked River groundwater from the east slope of the Cascades Mountains resurfaces as springs recharging the streamflow with cool water. Summer readings at the Opal gauge near Culver average 1250 cfs just upstream from Lake Billy Chinook. This results in favorable water quality and quantity conditions for resident redband trout and introduced steelhead, however, the reach is spawning gravel limited.

Hydrology in lower McKay Creek has been significantly altered as well downstream of the Ochoco National Forest boundary at Rm 14. Irrigation withdrawals frequently dewater the creek from this point downstream to Rm 5 during the irrigation season. At Rm 3.5 and Rm 5 Ochoco Irrigation District's main canals bisect McKay Creek at each of these points 1-10 cfs of water is diverted from the canal and the creek serves as a conduit to deliver irrigation water to downstream customers. This results in artificially favorable flows in this reach of McKay Creek that supports a healthy redband trout population despite relatively degraded habitat conditions.

Altered sediment routing
Sediment deposition and substrate composition in the lower Crooked River recovery area are altered through two pathways. The mainstem reach from Prineville to Lone Pine and most of the Ochoco and McKay Creek watersheds have degraded riparian areas, poorly functioning channels and unstable banks. These conditions result in high levels of fine sediment incorporated into available spawning gravel. Conversely, the mainstem reach below Bowman Dam receives little sediment impact from eroding banks but has chronic high turbidity levels resulting from fine sediments released from Prineville Reservoir. Bowman Dam also serves to limit gravel recruitment, which may limit steelhead production, into this reach. In general, the reaches with the highest water quantity and quality have limited amounts of spawning gravel, while the reaches with abundant gravel are water and sediment limited. The one reach in the reintroduction area currently with fair to good conditions for both spawning and rearing is the mainstem Crooked River from Prineville (Rm 51 to Rice Baldwin Dam Rm 55). The lower five miles of McKay Creek and the eight miles within the Ochoco National Forest as well as the ten miles of Ochoco Creek from the mouth to Ochoco Dam also have moderate potential to support each steelhead life history stage.

Impaired fish passage
Artificial barriers are a significant limiting factor for steelhead production in the Crooked River. However, ongoing efforts by ODFW, the Crooked River Watershed Council, U.S Fish and

Wildlife Service, Natural Resource Conservation Service and others are making progress at addressing several barriers. The Pelton-Round Butte Complex represents the paramount impediment to steelhead passage into upper Deschutes Basin including the Crooked River. Development of passage facilities is a FERC license condition to operate the hydroelectric project. Passage efforts here are discussed elsewhere in this document.

A second large barrier to upstream fish migration into the Crooked River is Opal Springs Dam at Rm 7, approximately one mile upstream from the Crooked River Arm of Lake Billy Chinook. This is a 24 foot high concrete dam owned and operated by Deschutes Valley Water District. It was constructed in 1982 as part of a FERC licensed hydroelectric project. At the time of licensing passage was not required. The license does not expire until 2032, however, numerous stakeholders are working collaboratively with the dam operator to construct passage facilities at Opal Springs with an estimated completion date in 2012.

There are four additional concrete irrigation dams on the mainstem Crooked River between Opal and Bowman Dams. The Crooked River Watershed Council and others completed construction of passage facilities at the Crooked River Central and People's Irrigation District Dams at Rms 44 and 51 respectively in January 2009. The Rice Baldwin and Stearns Dams remain partial barriers with the former passable by adult fish at all flows and the later passable to adults at high flows. Discussions are underway to improve passage at Stearns Dam in the near future.

Both Crooked River major tributaries, Ochoco and McKay Creeks had numerous seasonal and permanent barriers prior to the 1998 flood in Prineville. Ochoco Irrigation District alone had eleven permanent or seasonal barriers in the two creeks prior to the flood. The irrigation district worked collaboratively with ODFW, OWEB and others to replace each of these diversions with state of the art structures. Currently there is one seasonal barrier on Ochoco Creek and two permanent partial barriers on McKay Creek. ODFW and the Watershed Council are engaged with private landowners to provide passage at each of these sites.

Upper Crooked River Watershed Limiting Factors

The upper Crooked River watershed includes the mainstem, North Fork, South Fork, Bear Creek and Beaver Creek above Bowman Dam and Ochoco Creek and Mill Creek above Ochoco Dam. The entire upper subbasin was historically inhabited by summer steelhead with the exception of the North Fork Crooked River that had a largely impassable natural barrier (Lower Falls) nine miles upstream from the mouth. However, these historic habitats are not in the current Mid Columbia steelhead reintroduction area.

Limiting factors in the upper watershed are largely similar to the lower watershed. A notable exception is the water quality and quantity issues in the mainstem above Prineville Reservoir are more pervasive. Summer flow is routinely below 5 cfs with stream temperatures in the mid 80s. Suitable steelhead production areas are fragmented are largely disconnected from viable migration and rearing areas. Conversely, the upper Ochoco watershed has considerable steelhead production potential. The Mill Creek watershed in particular has had considerable restoration work and could be one of the most productive streams in the subbasin. Altered hydrology is the primary limiting factor in upper Ochoco as well.

A summary of the major limiting factors and threats for the Crooked River steelhead population by geographic area is presented in Table 8-19.

Table 8-19. Habitat limiting factors summary for the Crooked River steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Potential Causes/Threats	Life Stages Affected
CROOKED RIVER POPULATION					
Crooked River Population	Degraded riparian communities; degraded floodplain and channel structure (complexity, side-channel habitat, diversity); water quality (temp); altered hydrology (low flow); altered sediment routing; blocked and impaired fish passage	MaSAs and MiSAs	Abundance, productivity, spatial structure, diversity	Primarily livestock grazing, residential development and agricultural practices that simplify habitat, irrigation withdrawals, unauthorized OHV use, dams and other barriers, reservoir release flows	All life stages
Crooked confluence MISA (reintroduction)	Limited spawning habitat, passage	Crooked River (Rm 6 – Rm 7) BP	Productivity, abundance, spatial structure and diversity	Barrier at Opal Springs Dam	Spawning
Lone Pine MISA (reintroduction)	Limited spawning habitat	Crooked River (Rm 7 –Rm 20)	Productivity, abundance, spatial structure and diversity		Spawning
McKay MASA (reintroduction)	Degraded channel structure; water quality (temp), altered hydrology, degraded riparian communites, altered sediment routing, passage	McKay Cr. (Rm 0 - Rm 14) including Allen Cr. F, CS, R, H, S, T, BP; McKay Cr. (Rm 14-Rm 19) including Little McKay Cr.CS, R, S, WQ	Productivity, abundance, spatial structure and diversity	Past channelization, livestock grazing and agricultural practices, irrigation withdrawals, unauthorized OHV use, permanent and seasonal barriers, removal of riparian vegetation, loss of LWD	All life stages
Lower Ochoco MASA (reintroduction)	Degraded channel structure and reduced complexity, altered hydrology, degraded riparian communites, altered sediment routing,	Ochoco Cr (Rm 0 – Rm 10) F, CS, R, H, S, IP	Productivity, abundance, spatial structure and diversity	Urban development in reach through Prineville, flow management in releases from Ochoco Dam. Livestock grazing and agricultural practices in upper reach below Ochoco Dam	All life stages
Lower Crooked MASA (reintroduction)	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp, pollutants); altered sediment routing	Crooked River (Rm 20 – Rm 56) F, CS, R ,H, WQ, T, S; Crooked River (Rm 56 – Rm 70) H, WQ, S, BP	Productivity, abundance, spatial structure and diversity	Livestock grazing and agricultural practices, past channelization, flow management or releases from Bowman Dam, irrigation withdrawals	All life stages
Upper Ochoco MASA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp, pollutants); altered sediment routing	Mill Creek (Rm 0-Rm 15) F, CS, H, T; considerable restoration has occurred. Ochoco Cr. (Rm 14-Rm 32) F,CS,R, H, T, S; Wolf Cr. (Rm 0 – Rm 4). CS, R; Marks Cr. (Rm 0-	Productivity, abundance, spatial structure and diversity	Livestock grazing and agricultural practices, past channelization, irrigation withdrawals, roads , forest management	All life stages

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Potential Causes/Threats	Life Stages Affected
		Rm 8) CS, T, S, BP			
Upper Crooked, South Fork Crooked, Beaver Cr MASAs, Bear Cr. MISA	Degraded floodplain and channel structure; degraded riparian communities; altered hydrology; degraded water quality (temp, pollutants); altered sediment routing	Crooked R (Rm 86 – Rm 125) and tribs. F,CS,R,H,T,S , BP (Horse Heaven Cr), IP; South Fk Crooked (Rm 0 – Rm 20) CS, R, H, T, S, IP; Beaver Cr.(Rm 0 – Rm 25) and tribs F,CS, R, H, T, S,; North Fk Crooked (Rm 0 – Rm 9) CS, R, H, T	Productivity, abundance, spatial structure and diversity	Livestock grazing and agricultural practices, past channelization, irrigation withdrawals, roads, forest management	All life stages

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F), degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), high water temperatures (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.5 Lower Mainstem John Day River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified for this population are: degraded floodplain and degraded channel structure (key habitat quantity and habitat diversity), altered sediment routing, water quality (temperature), and altered hydrology. Obstructions are high priority limiting factors in Bridge, Kahler, Muddy, Rock (lower in Gilliam County), and Thirtymile creeks.

Degraded floodplain connectivity and function
Land cover in the lower John Day River watershed is predominately rangeland and cropland (ODA 2004). Floodplains and riparian areas have been extensively altered by agriculture, livestock grazing, transportation corridors, and other development.

Degraded channel structure and complexity
The lower reaches of tributaries in many MaSAs and MiSAs for this population have had extensive channel modifications. Channelization and streambank hardening are extensive, affecting channel conditions and dynamics. Habitat diversity and LWD are also lacking, and overall habitat complexity is well below benchmark condition. Examples include lower Bridge, Mountain, Rock (Wheeler County), Cottonwood, Ferry Canyon, Pine Hollow, and Thirtymile**.** Conditions improve upstream in many of the streams that flow out of the Bridge Creek Wilderness, including Bridge, Mountain, and Rock (Wheeler County), as well as Cottonwood Creek, that flows out of a roadless area.

Kahler and Service creeks have low levels of LWD and overall habitat complexity. EDT results identified habitat diversity as a medium priority limiting factor and key habitat quantity as a high priority. Ferry Canyon has an incised channel that is generally unstable, though conditions have improved recently. Pine Hollow has a pipeline buried in the channel for 6.6 miles, which in

combination with the 1964 flood, contributes to a very unstable channel. Channel conditions in Thirtymile Creek are generally degraded, with low levels of LWD and habitat complexity. Habitat complexity in Butte Creek is generally higher, with rearing occurring throughout the system. Rock Creek (Gilliam County) channel conditions are degraded, with areas that have been channelized and have low levels of LWD.

Altered sediment routing
EDT findings indicated that sediment impacts in the Lower John Day watershed are higher than elsewhere in the subbasin (NPCC 2005). Sediment problems are often associated with changes in native plant communities due to wheat farming, grazing, and other activities that can cause severe streambank erosion and sedimentation. Forest and other roads, if not constructed and maintained with best management practices, can contribute to altered sediment routing. EDT results show sediment as a high priority limiting factor in Bridge, Butte, Grass Valley, Muddy, Scott Canyon, Lower and Upper Rock (Gilliam County), Thirtymile, Pine Hollow, and Mountain creeks, and gravel embeddedness as a significant limiting factor in the lower watershed.

Altered hydrologic processes
The USGS-maintained gage at McDonald Ferry, Oregon at RM 21, the oldest gage in the subbasin, has been in operation since December 1904. The lowest recorded discharge from the McDonald Ferry station was zero cfs for part of September 2, 1966, August 15 to September 16, 1973, and August 13, 14 and 19-25, 1977. Peak flow at the McDonald Ferry gaging station is typically more than 100 times greater than the lowest flows of the same year. From year to year, peak flows can vary as much as 300 to 700%. This portion of the watershed is prone to intense thunderstorms, which can scour channels down to bedrock, during summer months.

According to NMFS 2005, water withdrawals, riparian corridor alterations, grazing, channel alterations, and wetland loses have all contributed to lower base flows. Low flows are below benchmark in the lower reaches of Bridge, Cottonwood, and Mountain creeks. Flows are also below benchmark in Ferry Canyon, Pine Hollow, Thirtymile, Lower Rock (Wheeler County), and Butte. Water diversions contribute to reduced summer low flows in most of these areas.

EDT results rated "flow" as either a medium or low priority for restoration in 16 out of 18 reaches in the Lower John Day, though the subbasin planning technical team considered flow restoration a higher priority for several reaches. Flow is not a restoration priority for the lower John Day River McDonald Ferry reach since it is frequently inundated by backwaters from the John Day reservoir. Flow restoration would improve several other limiting factors addressed by EDT including habitat complexity and temperature.

Degraded water quality
From July to September, groundwater provides much of the base flow to the Lower John Day River (NPCC 2005). Elevated temperature is an important limiting factor for most stream segments for the Lower John Day population that are measured (ODA 2004).

BLM (1999) characterized temperature as "Not Properly Functioning" for all streams rated in the lower John Day. Other water quality constituents such as total phosphates, biological oxygen demand, and fecal coliform can also limit water quality in late summer when flows are lowest

and water temperatures are the greatest. Cottonwood, Rock (Wheeler Co) and Bridge have good quality water in their upper reaches, but water quality conditions, especially temperature, degrade in the lower reaches. Butte Creek has water quality that supports rearing throughout the stream. Table 8-20 shows 303(d) listed streams in the Lower John Day watershed.

Table 8-20. Lower John Day watershed 303(d) listed stream segments and parameters of concern (ODEQ 2002 cited in NPCC 2005). Waterbodies that are listed multiple times represent different locations and/or different life stages.

Waterbody Name	Parameter	Waterbody Name	Parameter
Bear Creek	Temperature	John Day River	Temperature
Bridge Creek	Temperature	John Day River	Temperature
Gable Creek	Temperature	John Day River	Fecal Coliform
Grass Valley Canyon	Temperature	John Day River	Dissolved Oxygen
Henry Creek	Temperature	Nelson Creek	Temperature
John Day River	Fecal Coliform	Pine Creek	Biological Criteria
John Day River	pH	Sorefoot Creek	Temperature
John Day River	Temperature	Stahl Canyon	Temperature
John Day River	Temperature	Thirtymile Creek	Temperature

Blocked or impaired fish passage
EDT results identified "obstructions" as a high priority limiting factor in Bridge, Kahler, Muddy, Lower Rock (Gilliam County), and Thirtymile creeks, and a medium priority in Rock Creek (Wheeler County). The passage barrier on Bridge Creek is near the town of Mitchell and is considered passable to adults. The passage barrier on Kahler Creek is low in the system and only a juvenile barrier. Irrigation diversions create passage barriers on Lower Rock Creek (Gilliam County). Some of these have been repaired, but others have not. A fish passage structure was installed recently on Thirtymile Creek. None of the passage barriers identified are complete barriers, except for the one on Muddy Creek. ODFW biologists also identified passage problems on Mountain Creek (Unterwegner 2005).

Many irrigation diversions occur within the John Day subbasin watershed and, in low-water years, fish may encounter passage and spawning difficulties in some tributary reaches due to these diversions. Flows necessary for migration may be unavailable during early summer months and low-flow conditions may limit the use of some potential spawning areas (NMFS 2003a).

Degraded riparian communities and large wood recruitment
Riparian conditions have been degraded by agriculture, grazing, stream channelization, and riparian roads, and other development and activities. EDT rated riparian habitat improvements as "high" to "very high" priorities for restoration in all reaches of the lower John Day watershed. Reaches of Lower Rock (Gilliam County), Kahler, Service, Pine Hollow, and Thirtymile have very poor riparian conditions. Riparian conditions are fairly good in the Bridge Creek Wilderness areas of Bridge, Mountain and Rock (Wheeler County) creeks and in the inventoried roadless area of Cottonwood Creek. Many reaches of Ferry Canyon and Pine Creek also have good riparian cover. Butte has generally fairly good riparian cover, except for isolated areas.

Table 8-21 shows limiting factors and priorities identified by EDT diagnostic reports for the Lower John Day steelhead population. A summary of major limiting factors and threats by geographic area is presented in Table 8-22.

Table 8-21. Limiting factors and priorities for protection and restoration as defined by EDT for the Lower Mainstem John Day River steelhead population.

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Bridge Creek	C	A	D				D		B		A				A	C		A
Butte Creek	E	A	D				D		B				D		A	C		A
Fields Creek									A						E			A
Grass Valley Canyon			D				B		E				D	D	A	C		B
JDR Johnson Creek	E	A	D				B		B				D	D	B	C		B
Lower JDR Clarno	E		D		D				B				D	D	B	C		B
Lower JDR Ferry Canyon		E	D		D		B		B				D	D	B	C		B
Lower JDR Kahler Creek	E	A	D				B		B		A		D		B	C		A
Lower JDR McDonald Ferry	C				D				A					B	A	E		B
Lower JDR Muddy Creek	C	A	D				B		B		A		D	D	A	C		B
Lower JDR Scott Canyon	E	A	D		D		B		B				D	D	A	C		B
Lower JDR Service Creek		C	D				B		B				D	D	B	C		A
Lower NF JDR									D							C		B
Lower Rock Cr		E	D				B		B		A				A	E		B
Mountain Creek	C	A	A				E		B				D		B	C		B
Pine Hollow		E	D				B		B	E			D		A	C		A
Rock Creek	A	C	A				E		E		B				B	E		B
Thirtymile Creek		A	D				B		B		A		D	D	A	B		A
Upper Middle JDR	A	A	D				E		B				D		B	C		B
Upper Rock Creek		C	D				B		B						A	C		A

Key to strategic priority (corresponding Benefit Category letter also shown)

A High — B Medium — C Low — D & E Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Table 8-22. Habitat limiting factors summary for the Lower Mainstem John Day River steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
LOWER MAINSTEM JOHN DAY POPULATION					
Lower Mainstem John Day Population	Altered hydrology (low flow); degraded water quality (temp); degraded floodplain and channel structure (complexity, diversity, pools); degraded riparian community; altered sediment routing	MaSAs and MiSAs	Productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, roads, irrigation withdrawals, wetland draining and conversion, diking and stream channelization	Juvenile rearing, egg incubation, egg-to-fry survival, fry-to-smolt survival. One-year smolts present at reduced level.
Ferry MaSA	degraded floodplain and channel structure; altered hydrology	Ferry Canyon [H, F, CS]	Productivity, abundance	Agricultural and livestock grazing practices	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Middle Rock (Gilliam) MaSA	Altered sediment routing; degraded water quality (temp); degraded floodplain and channel structure; altered hydrology	Rock Cr. [F, CS]	Productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Pine Hollow MaSA	Altered hydrology, degraded riparian communities; altered sediment routing; degraded water quality (temp); degraded floodplain and channel structure	Pine Hollow Cr. [F, CS (lower, pipeline), S,H,R]	Productivity, abundance, spatial structure, diversity	Agricultural activities, livestock grazing	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Upper Rock (Gilliam) MaSA	Altered sediment routing; degraded water quality (temp); altered hydrology; degraded floodplain and channel structure	[F, CS, S]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals and forest practices	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Lower Rock MaSA	degraded riparian communities; altered sediment routing; altered hydrology; impaired fish passage; degraded floodplain and channel structure; water quality (temp)	Rock Cr. [R, IP (lower), H,S,F, CS]	Reduced productivity, abundance, spatial structure, diversity	Agricultural activities, livestock grazing, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Thirtymile MaSA	impaired fish passage; altered hydrology, degraded floodplain and channel structure; altered sediment routing; water quality (temp); degraded riparian communities	Thirtymile Cr. [F, CS (lower especially), S,H,R,IP,T]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and forest practices activities, livestock grazing, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Bridge MaSA	impaired fish passage; degraded floodplain and channel structure; altered sediment routing; water quality (temp); altered hydrology	Bridge Cr. [F, CS,R,H (lower), IP (near Mitchell), S,T]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
Mountain MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp); altered hydrology; impaired fish passage	Mountain Cr. [F, CS, H (lower), S, IP]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Rock (Wheeler) MaSA	degraded floodplain and channel structure; water quality (temp); altered hydrology	Rock [F, CS (lower), H, IP]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Kahler MaSA	Altered hydrology; degraded floodplain and channel structure; impaired fish passage; altered sediment routing; water quality (temp); degraded riparian communities	Kahler Cr. [IP (lower), F, CS, R,]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Butte MaSA	Altered hydrology; degraded floodplain and channel structure; altered sediment routing; water quality (temp), degraded riparian communities in isolated reaches	Butte Cr. [H, S (lower)], R	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Service MaSA	degraded floodplain and channel structure; degraded riparian communities; altered hydrology; altered sediment routing; water quality (temp)	Service Cr. [F, CS, R]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts
Cottonwood MaSA	Altered hydrology; water quality (temp)	Cottonwood Cr. [H, F, CS (lower reaches)]	Reduced productivity, abundance, spatial structure, diversity	Agricultural and livestock grazing practices, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-fry, fry-to-smolt, one-year smolts

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F), degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.6 North Fork John Day River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for the North Fork John Day River steelhead population are degraded floodplain connectivity and function, degraded channel structure and complexity (key habitat quantity, habitat diversity, channel stability), altered sediment routing, water quality (temperature), and altered hydrology.

Degraded floodplain connectivity and function
Floodplain connectivity in several reaches of the Granite Creek system has, until recently, been limited by dredge piles from historical mining operations. Many of these historical dredge piles sat very near the stream and prevented the stream from overflowing into the floodplain during

high flow events. During the last five years, many of the tailing piles along Granite and Clear creeks have been leveled and floodplain connectivity has been re-established. However, a high flow event is needed to reconfigure the channel and create the necessary pool frequency.

Degraded channel structure and complexity
Most indicators of channel condition within the North Fork John Day River are "functioning at risk" (NMFS 2003). The North Fork River does not meet PACFISH pool frequency management objectives (USDA and USDI 1994 cited in NPCC 2005). Key habitat quantity is identified by the EDT analysis as the most important limiting factor to address for this population. Pool frequency and quality limit production in the Granite Creek and upper North Fork systems. Degraded channel conditions also limit steelhead production in the Big Wall Creek drainage (NMFS 2003). Middle Camas and lower Owens Creek watersheds have good potential; however, stream channels are incised, LWD is low, and habitat diversity is limited. Large pools, channel habitat, wetted width/maximum depth ratio, and streambank condition are considered properly functioning in the Granite Creek subwatershed.

Altered sediment routing
Erosion caused by forest practices and other activities affects habitat conditions in several parts of the North Fork drainage. The Wallowa Whitman National Forest (WWNF) has identified sediment as "functioning at risk" in both the Granite Creek and Upper North Fork John Day subwatersheds. The Umatilla National Forest (UNF) considers sediment to be "not properly functioning" and substrate embeddedness to be functioning at risk in the Big Wall Creek subwatershed (NMFS 2003). Big Wall Creek was listed on the 303(d) list for sediment. Sediment modeling conducted for the parts of the Big Wall Creek subwatershed indicates that only prescribed fire and instream habitat improvement posed more than negligible risk of sediment increases (NMFS 2003). Wissmar et al. (1994) noted that turbidity in Cottonwood Creek, a North Fork tributary, is notoriously high after storm events. The resulting siltation of stream beds decrease aquatic insect production and degrades spawning habitat.

Altered hydrologic processes
Water yield is generally close to benchmark conditions in most of the upper reaches and tributaries to the North Fork John Day, where much of the watershed is protected as a wilderness area. Low flows are more a problem in the lower elevation tributaries to the west including the lower reaches of Big Wall, Cottonwood, and Rudio. EDT results identified flow as a medium priority restoration need in Cottonwood Creek and as a low restoration priority for Granite, upper and lower Camas, and the lower North Fork John Day River.

The Pete Mann ditch system in the Granite Creek watershed is a complex of ditches originally constructed in the late 1800s to deliver water to local mines. Currently, the ditch system delivers water to both mines and land irrigated for agriculture. The Pete Mann ditch system often completely diverts Lightning Creek, Salmon Creek, and the East Fork Clear Creek (all steelhead streams) into the Burnt River subbasin, a non-anadromous basin. Although the Forest Service did not rate change in peak/base flows, it is likely that this indicator is functioning either "at risk" or "not properly functioning" because of this ditch system.

Degraded water quality

The North Fork has the best chemical, physical, and biological water quality in the John Day subbasin as compared to ODEQ water quality standards (USDI 2000 cited in NPCC 2004). Most of the streams in this subbasin are considered in relatively good condition, with the exception of elevated late summer water temperatures that do not meet ODEQ standards (Table 8-23). Water temperature is primarily a concern in Cottonwood Creek, the lower North Fork John Day and lower reaches of Granite Creek. Because the North Fork (including its primary tributary, the Middle Fork) contributes 60% of the flow to the mainstem John Day (OWRD 1986), the influence of the North Fork on temperature is significant.

Leaching of toxic mine waste and a high degree of stream sedimentation from highly erodible, decomposing granitic soils also create water quality problems in the North Fork. Waste from abandoned mine sites may be having serious negative effects on water quality in the upper North Fork John Day and Granite Creek watersheds, where ODFW biologists have observed dead fish and adult spring Chinook with gill lesions (NMFS 2003; Wilson et al. 2005a). The cause of this mortality is not certain, but elevated iron and heavy metal concentrations may be a contributing factor. While recent surveys conducted by the UNF and U.S. Environmental Protection Agency indicate that mercury was not present in high enough concentrations known to cause these types of effects, conditions at abandoned mine sites and abatement ponds may change yearly, increasing the amount of heavy metals released (NMFS 2003). Hot geothermal springs also exist, but their effects on water quality are not fully known (NPCC 2005).

Table 8-23. North Fork John Day River subbasin 303(d) listed stream segments and water quality parameters of concern (ODEQ 2002 cited in NPCC 2005).

Waterbody Name	Parameter	Waterbody Name	Parameter
Alder Creek	Sedimentation	Hidaway Creek	Temperature
Baldy Creek	Sedimentation	Hog Creek	Sedimentation
Bear Wallow Creek	Temperature	Indian Creek	Temperature
Beaver Creek	Temperature	Lane Creek	Temperature
Big Creek	Temperature	Mallory Creek	Temperature
Big Wall Creek	Temperature, Sedimentation	Meadow Creek	Temperature
Bowman Creek	Temperature	North Fork Cable Creek	Temperature
Bridge Creek	Temperature	North Fork John Day River	Temperature
Buck Creek	Temperature	Onion Creek	Temperature
Bull Run Creek	Temperature	Owens Creek	Temperature
Cable Creek	Temperature	Porter Creek	Sedimentation
Camas Creek	Temperature	Potamus Creek	Temperature
Clear Creek	Temperature	Rancheria Creek	Temperature
Cottonwood Creek	Biological Criteria	Skookum Creek	Temperature
Crane Creek	Temperature	South Fork Cable Creek	Temperature
Desolation Creek	Temperature	South Trail Creek	Temperature
Ditch Creek	Temperature	Sponge Creek	Temperature
East Fork Cottonwood Creek	Biological Criteria	Stalder Creek	Temperature
Fivemile Creek	Temperature	Swale Creek	Temperature, Sedimentation
Frazier Creek	Temperature	Trail Creek	Temperature
Granite Creek	Temperature, Sedimentation	Wilson Creek	Temperature, Sedimentation

Blocked or impaired fish passage
Physical barriers in the Big Wall Creek and Granite Creek drainages are considered to be "functioning at risk" (NMFS 2003). Currently a number of culverts on forest land from partial passage barriers for steelhead (USFS 2001).

Degraded riparian communities and large wood recruitment
Much of the Upper North Fork watershed is designated as wilderness and is likely at or near benchmark condition. Riparian conditions are also likely near benchmark conditions in the Potamus and Stony watersheds where access and road densities are very limited. Riparian conditions are considered to be "functioning at risk" in the Big Wall and Granite watersheds. The active recent fire history has caused some changes in riparian conditions. Large fires in Desolation Creek, Upper North Fork John Day, and Granite Creek from 1986-1996 modified stream shade and sediment routing in some locations.

Table 8-24 provides information from EDT Diagnostic Report on limiting factors for each HUC5 occupied by the North Fork John Day steelhead population. A summary of limiting factors and threats by geographic area is presented in Table 8-25.

Table 8-24. Limiting factors and priorities for protection and restoration as defined by EDT for North Fork John Day Steelhead.

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Cottonwood Creek		◯	●				●		●				•		●	●		●
Desolation Creek	◯	○	•												●	•		●
Granite Creek	○	○	•				•		•						●			●
JDR Johnson Creek									•					•	•			●
Lower Camas Creek	○	○	•				•		●						●	•		●
Lower JDR Clarno	○								•					•				●
Lower JDR Ferry Canyon									•					•				●
Lower JDR Kahler Creek	○						•		●							•		●
Lower JDR McDonald Ferry	○								•					●				
Lower JDR Muddy Creek	○								●					•				●
Lower JDR Scott Canyon	○								•					•				●
Lower JDR Service Creek	○						•		●						•	•		●
Lower MF JDR									●							●		•
Lower NF JDR	○	○	•				•		●				•		●	●		●
NF JDR Big Creek	◯	◯	●						•		●				•	•		●
NF JDR Potamus Creek	○	◯	•				•		●						●	•		●
Upper Camas Creek	○	○	•				•		•						●	•		●
Upper NF JDR	◯	◯	●						•						●	•		●
Wall Creek	○	○					●		•						●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

A ◯ / ● High B ○ / ● Medium C ○ / • Low D & E Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Table 8-25. Habitat limiting factors summary for the North Fork John Day River steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
NORTH FORK JOHN DAY POPULATION					
North Fork John Day Population	degraded floodplain and channel structure (pools, connectivity, diversity); altered sediment routing; water quality (temp, toxic mine waste)	MaSAs and MiSAs	Productivity and abundance most affected; possible slightly altered spatial structure.	Riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, irrigation withdrawals, mining and dredging	Parr-to-smolt survival and egg-to-fry survival. All stages affected by toxic leaching in Granite Cr. and NF John Day R.
Lower Camas MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp)	Camas between Hideaway and Wilkins (T, F, CS, R, H, S	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads,	Parr-to-smolt survival and egg-to-fry survival.
Potamus MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp)	Potamus [T,S,F,CS]	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads,	Parr-to-smolt survival and egg-to-fry survival.
Big Wall MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp); altered hydrology	[H (lower), F, CS,S,T,IP,R]	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads,	Parr-to-smolt survival and egg-to-fry survival.
Upper NF John Day MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (toxic mine waste)	[WQ (mine sites), F,CS,S,]	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads, mining and dredging	Primarily parr-to-smolt and egg-to-fry survival. All stages affected by toxic leaching
Desolation MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp)	[F,CS,S,T]	Productivity and abundance most affected; slightly altered spatial structure	Livestock grazing, forest practices, roads,	Primarily parr-to-smolt and egg-to-fry survival.
Granite MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (toxic mine waste); altered hydrology	[H (Pete Mann ditch system), WQ (mine sties), F,CS, S,T,R]	Productivity and abundance most affected; possible slightly altered spatial structure	forest practices, roads, mining and dredging	Parr-to-smolt and egg-to-fry survival. All stages affected by toxic leaching
Cottonwood MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp); altered hydrology; degraded riparian communities	[H, IP (lower reaches), F,CS, S, WQ, R (biological criteria)]	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads, irrigation withdrawals	Primarily parr-to-smolt and egg-to-fry survival.
Owens MaSA	degraded floodplain and channel structure	[F, CS, S, T]	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads, irrigation withdrawals	Primarily parr-to-smolt and egg-to-fry survival.
Upper Camas MaSA	degraded floodplain and channel structure; altered sediment routing; water quality (temp)	[F, CS, S, T,]	Productivity and abundance most affected; possible slightly altered spatial structure	Livestock grazing, forest practices, roads	Primarily parr-to-smolt and egg-to-fry survival.

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F); degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.7 Middle Fork John Day River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for Middle Fork John Day steelhead are degraded floodplain and channel structure (key habitat quantity and habitat diversity), altered sediment routing, altered hydrology, and water quality (temperature).

Degraded floodplain connectivity and function
Channels have become disconnected from their floodplains in several areas of the Middle Fork John Day watershed (Malheur National Forest (MNF) 1999). A number of areas with very wide grassy valley bottoms historically were likely Rosgen E-channels but have been altered to type G and C channels by past overgrazing and road construction within floodplains (MNF 1999). Known areas with this condition include the mainstem Middle Fork John Day River, Squaw Meadow, Summit Creek and Squaw Creek near their mouths, and Olmstead Creek at Olmstead meadows. Floodplains along the Middle Fork and tributaries were also altered by mining operations.

Degraded channel structure and complexity
Tributaries to the Middle Fork that flow out of the Dixie Divide between the Middle Fork John Day and the Upper John Day are generally steep and incised in the lower reaches. Long, Squaw and Camp creeks flow through low-gradient meadow systems in the upper reaches. Tributaries that flow out of the Elkhorn Mountains to the north do not generally have meadow systems in their upper reaches, and the base rock is granite. Portions of Bridge, Dry Fork Clear, Crawford, Summit, and Squaw creeks have significant lengths of their channels impacted by streamside roads. EDT results identified habitat diversity and key habitat quantity as limiting factors in all major and minor spawning areas.

Mining operations have altered many of the stream channels and floodplains along the Middle Fork and its tributaries (MNF 1999). Alterations have occurred along Elk, Davis, Deep, Vinegar, Placer Gulch, Vincent, Caribou, Beaver, Granite Boulder, Big Boulder, Ragged, Butte, Ruby, and the Middle Fork mainstem. Some of the meadow areas have incised channels, including Phipps Meadow. Road construction has altered and constricted channels in many tributaries and along the Middle Fork mainstem. Log weirs, placed in lower Camp Creek, keep the channel from re-establishing its natural morphology.

Altered sediment routing
The BLM has identified sediment/turbidity and substrate embeddedness as "functioning at risk" in the Middle Fork John Day and a number of its tributaries (NMFS 2004/00383). EDT results identified sediment loading to be a significant limiting factor in the watershed. Excessive fine sediment problems are generally located in the Middle Fork mainstem (Unterwegner 2005). Poor riparian conditions, riparian roads, grazing activities, and past forestry, mining, and channel alterations all contribute sediment to streams in the watershed.

Altered hydrologic processes
The Middle Fork drainage is susceptible to rain-on-snow events capable of producing high volume, short duration run-off surges during the late winter and early spring months. Late

season base flows are sustained by slow release of water from the soil matrix, effluent groundwater, numerous wet meadows, and perennial springs (MNF 1999). Where channels have become entrenched, water tables are lowered and water storage capacity is reduced, resulting in lower base flows.

While low flows are a problem throughout the subbasin, irrigation withdrawals are not as significant as for some other populations in the John Day subbasin, or as significant as they were a few years ago. Most water rights in the upper Middle Fork subbasin are no longer being used for irrigating pastures. Four of the five largest water users above Highway 395 have converted their consumptive rights to instream rights for either the entire year or for the most critical low flow period. Three properties in the Middle Fork subbasin above Highway 395 continue to irrigate pastures with flood irrigation. One of the properties is located on Camp Creek, one is on the Middle Fork immediately above Camp Creek, and the other is near Galena.

Degraded water quality

Water quality in the Middle Fork subbasin generally exhibits satisfactory chemical, physical, and biological quality as compared to ODEQ water quality standards (USDI 2000 cited in NPCC 2005). The Middle Fork usually has worse water quality problems than its tributaries, with the most serious water quality problem being elevated summer temperatures. Season-long cattle grazing contributes to elevated fecal coliform counts during summer. However, agricultural runoff presents a low level of potential impact to water quality (NPCC 2001 cited in NPCC 2005). Flow from Bates Pond, an old mill pond on Bridge Creek less than 200 yards from its confluence with the Middle Fork, likely increases temperatures in the Middle Fork.

ODEQ has identified several streams in the Middle Fork subbasin as water quality limited for high temperatures, dissolved oxygen, or biological criteria, with the most serious water quality problem being elevated summer temperatures caused by vegetation disturbance, stream straightening/relocation, livestock grazing, forest practices, road building, irrigation water withdrawals, and historical mining and dredging (NPCC 2005). Table 8-26 provides data on listed stream segments in the Middle Fork subbasin.

Table 8-26. Middle Fork John Day River subbasin 303(d) listed stream segments and parameters of concern in 1998 and 2002 (ODEQ 2002).

Waterbody Name	River Mile	Parameter	Season	List Date
Big Creek	0 to 11.6	Temperature	Summer	1998
Camp Creek	0 to 15.6	Temperature	Summer	1998
Caribou Creek	0 to 3.6	Temperature	Summer	1998
Clear Creek	0 to 12.7	Temperature	Summer	1998
Coyote Creek	0 to 2.5	Temperature	Summer	1998
Crawford Creek	0 to 3.5	Temperature	Summer	1998
Davis Creek	0 to 6.8	Temperature	Summer	1998
Dry Fork Clear Creek	0 to 11	Temperature	Summer	1998
Granite Boulder Creek	0 to 8.1	Temperature	Summer	1998
Little Boulder Creek	0 to 2.1	Temperature	Summer	1998
Little Butte Creek	0 to 2.6	Temperature	Summer	1998
Long Creek	0 to 36.7	Temperature	Summer	1998
Lunch Creek	0 to 4.1	Temperature	Summer	1998
Middle Fork John Day River	0 to 69.8	Temperature	Summer	1998
Middle Fork John Day River	0 to 69.8	Temperature	August 15 - July 15	2002
Mill Creek	0 to 3.1	Temperature	Summer	1998
Placer Gulch	0 to 4.2	Temperature	Summer	1998
Ragged Creek	0 to 4.1	Temperature	Summer	1998
Squaw Creek	0 to 9.4	Temperature	Summer	1998
Summit Creek	0 to 8.6	Temperature	Summer	1998
Summit Creek	0 to 8.6	Temperature	August 15 - July 15	2002
Unnamed Waterbody	0 to 2.4	Temperature	Summer	1998
Vinegar Creek	0 to 7.1	Temperature	Summer	1998

Poage et al. (1996) studied stream temperatures along the length of the Middle Fork John Day River and found they differed from other subbasins of the John Day River. The average stream temperature profile for the Middle Fork John Day River indicated that the pattern of water temperature was highly variable, with the highest average water temperatures observed at the upstream end of the study section. The authors hypothesized that the decrease in downstream temperature can be explained by cold-water inputs from cooler tributaries, including Clear Creek, and as the result of relatively cool groundwater seeping into the main stream channel (Poage et al. 1996).

Blocked or impaired fish passage

Currently a number of culverts on forest land form partial passage barriers for steelhead (Unterwegner 2005). In the past, numerous pushup dams and irrigation diversions in the upper Middle Fork and several of its tributaries created intermittent passage barriers; they also increased sedimentation, seasonally reduced flows, altered channels, and caused other water quality impacts. Many of these irrigation diversions have been converted to permanent, more fish passage friendly structures within the last ten years. Water diversions that are not properly screened to prevent intake of juvenile Mid-C steelhead may still exist in the system, particularly

on Long Creek and other tributaries of the lower Middle Fork (NPCC 2001 cited in NMFS 2004a).

Degraded riparian communities and large wood recruitment

Riparian corridors and levels of instream LWD have changed significantly from historical conditions. The reduction in large wood has resulted in fewer pools, increased stream velocities, reduced sediment trapping, and an overall reduction in channel diversity and key habitat (MNF 1999). Exceptions include the Clear Creek and Lunch Creek watersheds that contain high levels of woody material and good riparian conditions. Weir "hard structures" have been constructed in Camp, Lick, Squaw, Summit, Phipps, Dry Fork Clear creeks, and the lower portion of Clear Creek in an attempt to increase pool habitat and instream diversity (MNF 1999).

Table 8-27 provides information from EDT Diagnostic Report on limiting factors for each HUC5 occupied for the Middle Fork John Day River steelhead population. A summary of major limiting factors and threats by geographic area is presented in Table 8-28.

Table 8-27. Limiting factors and priorities for protection and restoration as defined by EDT for Middle Fork John Day River steelhead.

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Big Creek	○	◯	•				•		•						●	•		●
Camp Creek	◯	◯	•				•		•						●	•		●
Cottonwood Creek			•				•		•									●
JDR Johnson Creek									•					•	•			●
Long Creek	○	○	•				●		●						●	•		◉
Lower JDR Clarno									•					•				●
Lower JDR Ferry Canyon		○							•					•				●
Lower JDR Kahler Creek	○						•		●							•		●
Lower JDR McDonald Ferry	○	○							•					●				
Lower JDR Muddy Creek									•					•				●
Lower JDR Scott Canyon		○							•					•				●
Lower JDR Service Creek									•					•				●
Lower MF JDR		○	•				•		●						●	●		●
Lower NF JDR									•							●		●
NF JDR Potamus Creek									●							●		•
Upper MF JDR	○	○	•				•		•						●			●
Wall Creek							•		•									●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A	B	C	D & E
◯ / ● High	○ / ● Medium	○ / • Low	Indirect or General

Table 8-28. Habitat limiting factors summary for the Middle Fork John Day River steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
MIDDLE FORK JOHN DAY POPULATION					
Middle Fork John Day Population	degraded floodplain and channel structure (connectivity, diversity, complexity); altered hydrology; altered sediment routing; water quality (temp); impaired fish passage	MaSAs and MiSAs	Productivity, abundance, spatial structure and diversity	Stream channelization and relocation, grazing, forest practices, road building, culverts and other passage barriers, irrigation withdrawals, mining and dredging	All life stages, especially fry-to-smolt survival, egg incubation; egg-to-parr survival, spawning
Long Creek MaSA	degraded floodplain and channel structure; altered hydrology; altered sediment routing; water quality (temp); impaired fish passage	Long Cr. [T (RM 0-36.7), IP,F,CS,H,S, R]	Productivity, abundance, spatial structure and diversity	Stream channelization and relocation, grazing, forest practices, road building, culverts and other passage barriers, irrigation withdrawals	All life stages, especially fry-to-smolt survival, egg incubation; egg-to-parr survival
Slide Creek MaSA	Degraded riparian communities, floodplain connectivity, channel structure, altered sediment routing	Slide (F,CS, S, R)	Productivity, abundance, spatial structure and diversity	Grazing management, forest practices	All life stages, especially fry to smolt survival and egg to fry survival
Rush Creek MaSA	Impaired fish passage, channel complexity, connectivity	Rush Creek irrigation diversion at RM 2.2 (IP, F,CS)	Productivity, abundance, spatial structure, diversity	Stream bottom road, effects of past grazing management	All life stages, especially fry to smolt survival and egg to fry survival
Upper MF John Day MaSA	Altered sediment routing; degraded floodplain and channel structure; altered hydrology; water quality (temp)	MF mainstem [T (RM 0-69.8), F,CS, S, H,R]	Productivity, abundance, spatial structure and diversity	Stream channelization and relocation, grazing, forest practices, road building, culverts and other passage barriers, irrigation withdrawals	All life stages, especially fry-to-smolt survival, egg incubation; egg-to-parr survival
Camp Creek MiSA	Degraded floodplain and channel structure; altered hydrology; water quality (temp); altered sediment routing	Lower Camp Cr. [T (RM 0 to 15.6), F,CS, S,T,R]	Productivity, abundance, spatial structure and diversity	Stream channelization and relocation, grazing, forest practices, road building, culverts and other passage barriers, irrigation withdrawals	All life stages, especially fry-to-smolt survival, egg incubation; egg-to-parr survival
Big Creek MiSa	Altered sediment routing; degraded floodplain and channel structure; altered hydrology; water quality (temp)	[T (RM 0-11.6), F,CS,S,T,R]	Productivity, abundance, spatial structure and diversity	Stream channelization and relocation, grazing, forest practices, road building, culverts and other passage barriers, irrigation withdrawals	All life stages, especially fry-to-smolt survival, egg incubation; egg-to-parr survival, spawning

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F); degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.8 South Fork John Day River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for the South Fork John Day River steelhead population are altered sediment routing, degraded floodplain and channel structure (key habitat quantity and habitat diversity), altered hydrology, water quality (temperature) and blocked or impaired fish passage.

Degraded floodplain connectivity and function
While the extent of floodplain connectivity has not been measured, ODFW considers this attribute as not properly functioning in sections of Murderers Creek below Cabin Creek. New beaver dams are contributing to improving off-channel habitats.

Degraded channel structure and complexity
Loss of beavers, active LWD debris removal projects, road construction, riparian timber harvests, and poor grazing management have accelerated water runoff and instream velocities in the South Fork system and led to increased channel and bank erosion, with incised and unstable channels (MNF 1997). Current stream bank surveys on the lower 14.6 miles indicate that the banks of Murderers Creek are between 98 and 100% stable. A riparian fence protects the stream bank along this reach except for in six water gaps used by cattle. Stream surveys conducted by ODFW in 1960 and the Malheur National Forest in 1997 showed that most reaches of Murderers Creek were deficient in LWD. Lower reaches of Murderers Creek are likely still deficient in LWD, but this condition is expected to improve as riparian vegetation recovers within the fenced riparian areas. Murderers Creek currently has few braided channels and backwaters. As the water drops in the summer, braiding and backwaters are reduced and flow is restricted to the channel. During low water and periods of high stream temperatures, distribution of juvenile steelhead is limited to cool water areas. Today, pool habitat is closer to benchmark conditions in the South Fork than generally found in the tributaries (Unterwegner 2005). There is more beaver activity in the creek than in the 1960s and the riffle-pool ratio has likely improved.

Altered sediment routing
Results from properly functioning condition (PFC) assessments conducted by the Malheur National Forest in 2004 in the South Fork and tributaries showed that sediment conditions in pool and riffle habitats were generally "not properly functioning" (MNF 2004). The MNF (2004) also noted that ongoing management of the existing road network associated with Reach 1 of Deer Creek is continuing to contribute excess gravel to the channel. The Forest Service lands within Deer Creek HUC5s have road densities of 4.14 miles of road/mile^2. This high road density may contribute to elevated sediment levels and embedded substrates in the South Fork and its tributaries.

The MNF (2004) also collected substrate embeddedness data for 40 streams in the South Fork watershed that showed substantial problems with embeddedness throughout the watershed. Out of 26 summaries, 21 were found to have more than 50% of the unit embedded (MNF 2004).

Roads might be the single most important threat causing the increases in sedimentation of streams (MNF 1997) because of density, location, and maintenance. Road densities on Forest Service lands in various HUC5s of the South Fork drainage are; 2.75 miles/mile² in Murderers Creek; 4.14 miles/mile² in Deer Creek; 4.25 miles/mile² in Middle South Fork; and 3.27 miles/mile² in Upper South Fork. The most heavily roaded areas are coincident with sedimentary soils in the upper watershed (MNF 1997). Surveys from 1992 to 1997 identified a number of reaches in the Murderers Creek watershed that were contributing excessive sediment to stream channels including, Beaver and North Fork Beaver, Miner, Grapefruit, Orange, Charley Mack, South Fork Murderers, Bark Cabin, Murderers (reach between Stewart's Cabin and Murderers Creek Guard Station), Oregon Mine, and Tennessee creeks.

Altered hydrologic processes
Livestock grazing, logging, road construction, beaver removal and fire suppression have all contributed to changes in peak/base flows in the South fork drainage. Further changes in the area's hydrology resulted from intensive stream channelization, flow modifications and drainage (including some tiling of drainage ditches) projects in the South Fork between 1943 and 1951. Irrigation withdrawals also reduce summer low flows in some reaches; however, overall, irrigation withdrawals and agricultural impacts in steelhead occupied reaches of the South Fork drainage are not as significant as for Upper Mainstem John Day or Lower John Day steelhead populations.

Low-flow conditions in Murderers Creek and other South Fork tributaries may limit the use of some potential spawning areas, even in unaltered habitat, due to the lack of water in early summer months. In some years, flows fall below recommended levels for successful spawning in Murderers Creek as early as May. Water temperatures and unsuitable habitat associated with naturally occurring low water conditions in Murderers Creek likely alter or temporarily block movement of juveniles during summer months (Harcombe and Unterwegner 2005).

Tributaries such as Black Canyon remain a source of good quality, cool water to the mainstem South Fork. The loss of beaver in the John Young Meadows in the upper South Fork Murderers Creek, where beavers were very active historically, has reduced the water storage capacity and led to entrenched channels downstream of the meadows (MNF 1997). MNF (1997) describes the Murderers Creek watershed as having a higher density of springs than most of the Bear Valley Ranger District. However, many of the tributaries flow only intermittently during the summer.

Degraded water quality
Elevated water temperatures during the summer months are considered a major limiting factor in the South Fork John Day River, Deer Creek, North Fork Deer Creek and Murderers Creek. All four streams are on the ODEQ's 303(d) list (ODEQ 2000). Monitoring by the stream gage near the mouth of Murderers Creek shows that water temperatures exceed 64ºF, 54% of the time (65 days out of 122 days) between July 1 and September 30, averaged over the 5-year period (ODFW 2005a). Elevated stream temperatures are also a problem in other major tributaries. Water withdrawals and agricultural impacts above Izee Falls contribute to water quality problems in occupied reaches of the lower South Fork (Unterwegner 2005).

Blocked or impaired fish passage

Izee Falls, at RM 28.5, is a complete natural block to steelhead migration. Water diversion structures and thermal barriers restrict juvenile steelhead passage at times. Irrigation withdrawals can also hinder upstream adult migration during late spring in very low water years.

Degraded riparian communities and large wood recruitment

Riparian areas are typically managed as part of range operations, and many have been altered from their natural state by water diversions, channelization, vegetation changes and the like (NPCC 2005). Grazing activities on the forest and private lands have impacted riparian functions by reducing or eliminating native plant communities, altering soil conditions and infiltration rates (MNF 1997; Kauffman 2004). Private, state and Federal forest practices have also altered riparian vegetation. These activities have reduced instream large wood concentrations and the potential for future large wood contributions. The MNF (2004) measured LWD in the South Fork watershed. Out of 28 streams, 15 streams met NMFS criteria of >20 pieces per mile of LWD >35 feet in length.

Table 8-29 provides information from EDT Diagnostic Report on limiting factors for the South Fork John Day River steelhead population. A summary of major limiting factors and threats by geographic area is presented in Table 8-30.

Table 8-29. Limiting factors and priorities for protection and restoration as defined by EDT for South Fork John Day River steelhead population.

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Fields Creek									●					●	●			⬤
JDR Johnson Creek	○						●		⬤						●	●		⬤
Lower JDR Clarno	○								●					●				⬤
Lower JDR Ferry Canyon	○								●					●				⬤
Lower JDR Kahler Creek	○								⬤							●		⬤
Lower JDR McDonald Ferry	○								●					⬤				
Lower JDR Muddy Creek	○								●					●				⬤
Lower JDR Scott Canyon	○								●					●				⬤
Lower JDR Service Creek	○								●					●				⬤
Lower NF JDR									●							⬤		⬤
Lower SF JDR	◯	◯	●				●		●						⬤	⬤		⬤
Middle SF JDR	○	○	●				●		●						⬤	●		⬤
Murderers Creek	○	○	●				●		●						⬤	●		⬤
Rock Creek									●							●		⬤
Upper Middle JDR							●		⬤							●		⬤

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A ◯ / ⬤ High — B ○ / ● Medium — C ○ / ● Low — D & E Indirect or General

***** Fields Creek, which is tributary to the JDR upstream of the SFJD, was included in the EDT analysis as part of the SFJD, but the TRT considers it a MiSA to the UJD population and it was discussed in the UJD population.

Table 8-30. Habitat limiting factors summary for the South Fork John Day River steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
SOUTH FORK JOHN DAY POPULATION					
South Fork John Day Population	Degraded floodplain and channel structure (lack of deep pools, habitat diversity); degraded riparian communities; water quality (temp); hydrologic alterations; sediment routing dysfunction; impaired fish passage	MaSAs and MiSAs	Productivity, abundance, spatial structure.	Riparian disturbance, stream channelization and relocation, roads, grazing, forest practices, culverts and other barriers, irrigation withdrawals, beaver removal	Juvenile rearing, spawning, egg incubation, egg-to-parr survival
Murderers Creek MaSA	Degraded floodplain and channel structure (lack of deep pools); hydrologic alterations; sediment routing dysfunction; water quality (temp); degraded riparian communities	Upper/Middle SF Murderers Cr. [F/CS, H, S, R]; Murderers Cr. [S, R, F/CS, T)	Productivity, abundance, spatial structure.	Riparian disturbance, stream channelization and relocation, roads, grazing, forest practices, culverts and other barriers, fire suppression, irrigation withdrawals, beaver removal	Juvenile rearing, spawning, egg incubation, egg-to-parr survival
Upper SF John Day MaSA	Degraded floodplain and channel structure; sediment routing dysfunction water quality (temp); hydrologic alterations; degraded riparian communities; impaired fish passage	Deer Cr. [Sed., R, F,T]; Upper SF John Day [T, F, S, BP, IP, R]	Productivity, abundance, spatial structure.	Irrigation withdrawals, agricultural practices, livestock grazing, stream channelization, road density	Juvenile rearing, spawning, egg incubation, egg-to-parr survival
Lower SF John Day MaSA	Degraded floodplain and channel structure; sediment routing dysfunction; water quality (temp)	Lower South Fork [T, S, F/CS]	Productivity, abundance, spatial structure.	Irrigation withdrawals and agricultural practices above Izee Falls, stream channellization, livestock grazing	Juvenile rearing, spawning, egg incubation, egg-to-parr survival

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F); degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.9 Upper Mainstem John Day River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for the Upper Mainstem John Day River steelhead population are degraded floodplain and channel structure (key habitat quantity and habitat diversity), altered sediment routing, water quality (temperature) and altered hydrology. Impaired fish passage is also a priority limiting factor for Beech and Laycock creeks.

Degraded floodplain connectivity and function
There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows. Degraded floodplain connectivity and function has led to more extreme flows and summer water temperatures.

Degraded channel structure and complexity
EDT results rated key habitat quantity as either a high or medium priority restoration need for all areas of the Upper Mainstem John Day River population and habitat diversity ranked as either a medium or low priority restoration need in all Upper John Day reaches (NPCC 2005). In addition, the Malheur National Forest rated LWD conditions and potential recruitment as "functioning at risk" in their Environmental Baseline for the Upper John Day (MNF 2004). Levels of big LWD are well below benchmark conditions for all areas outside wilderness boundaries (Unterwegner 2005, personal communication). Beech, Laycock, Fields, and Strawberry creeks are areas where restoration needs are highest for key habitat quantity and habitat diversity. Removal of beaver and their associated dams has reduced habitat complexity, floodplain function, and the amount of stored water. Livestock grazing has contributed to increased channelization, reductions in LWD, cover and bank stability, particularly in lower reaches of tributaries.

Altered sediment routing
Canyon Creek has a large supply of spawning gravels, with most good spawning habitat in upper meadow reaches. However, surveys of substrate embeddedness for the Upper John Day watershed show that, for measured streams, more than 50% of their summaries showed >35% embeddedness. Substrate embeddedness is a problem in 5 of 8 Canyon Creek reaches measured and 10 of 32 mainstem John Day reaches measured (MNF 2004).

Altered hydrologic processes
The upper John Day River experienced intensive stream channelization, flow modifications and drainage (including some tiling of drainage ditches) projects between 1943 and 1951. These and other activities altered the routing and timing of water delivery to streams; often increasing peak flows and reducing summer low flows. Irrigation withdrawals further reduce summer low flows, especially considering that the vast majority of the irrigation is from surface waters of the John Day and its tributaries (NPCC 2005). Livestock grazing, logging, road construction, beaver removal and fire suppression have all contributed to altered flow regimes. Today, summer low streamflows are below what would have existed historically. Water withdrawals dewater the lower reaches of Pine, Strawberry, Indian, Riley, Moon, McClellan, Laycock, and Fields creeks.

Degraded water quality
Water quality is fair in the upper watershed during most of the year, as compared to ODEQ water quality standards (USDI 2000 cited in NPCC 2005). Low summer flows on the mainstem John Day River above Dayville contribute to elevated temperatures; higher streamflows during the winter/spring and streambank erosion contribute to turbidity. Problematic eutrophication in the mainstem John Day River is a partial result of irrigation return flow and possibly cattle feedlots (NPCC 2001 from NPCC 2005). Table 8-31 lists stream segments within the Upper John Day watershed included on ODEQ's 303(d) list. Elevated stream temperatures are common to almost all the streams in the Upper John Day watershed. Historical mining has added to water quality problems by removing riparian vegetation, simplifying stream channels and changing stream substrate composition, all of which contribute to increased water temperatures.

Table 8-31. Upper John Day River watershed 303(d) listed stream segments and parameters of concern (ODEQ 2002). Waterbodies that are listed multiple times represent different locations and/or different life stages.

Waterbody Name	Parameter	Waterbody Name	Parameter
Badger Creek	Temperature	Grub Creek	Temperature
Battle Creek	Temperature	Indian Creek	Temperature
Bear Creek	Temperature	Little Pine Creek	Temperature
Canyon Creek	Temperature	McClellan Creek	Temperature
Corral Creek	Biological Criteria	Mountain Creek	Temperature
Cottonwood Creek	Temperature	Murderers Creek	Temperature
Dads Creek	Temperature	North Fork Deer Creek	Temperature
Dans Creek	Temperature	Pine Creek	Temperature
Deardorff Creek	Temperature	Rail Creek	Temperature
Deer Creek	Temperature	Reynolds Creek	Temperature
Dog Creek	Temperature	Reynolds Creek	Temperature
East Fork Canyon Creek	Temperature	Rock Creek	Temperature
Ennis Creek	Temperature	Slyfe Creek	Temperature
Ennis Creek	Temperature	South Fork John Day River	Temperature
Fields Creek	Temperature	Strawberry Creek	Temperature
Fields Creek	Temperature	Sunflower Creek	Temperature
Flat Creek	Temperature	Tex Creek	Temperature
Flat Creek	Temperature	Tex Creek	Temperature
Grasshopper Creek	Temperature	Tinker Creek	Temperature
Grasshopper Creek	Temperature	Utley Creek	Biological Criteria
		Utley Creek	Dissolved Oxygen

Blocked or impaired fish passage

Strawberry Creek has numerous unscreened ditches that may strand fish. Water withdrawals dewater the lower reaches of Pine, Indian, Strawberry, Moon, Laycock, McClellan, Riley, and Field creeks and create passage problems for juvenile fish. Diversions and low flows in Strawberry Creek create passage problems for adults as well. Push-up dams and other irrigation structures throughout the Upper John Day watershed often obstruct or delay fish passage. Culverts on national forest, state, county and private lands also create passage barriers in many areas. EDT results identified obstructions as high priority restoration needs in Beech and Laycock creeks**.** Panama Ditch crosses Beech Creek approximately one mile above its convergence with the John Day River forming a juvenile passage barrier, and possibly an adult barrier, at certain flows. High water temperatures in numerous tributaries and portions of the mainstem alter or sometimes block juvenile steelhead movements in the summer months.

Degraded riparian communities and large wood recruitment

Riparian conditions are generally degraded in the Upper John Day watershed. Roads along riparian corridors have altered riparian functions; the Malheur National Forest has identified 123.8 miles of roads within RHCAs in the Upper John Day watershed (MNF 2004). Forest practices on private and public lands have altered riparian vegetation and reduced LWD recruitment potential. Grazing activities on the forest and private lands have reduced or eliminated native plant communities, altering soil conditions and infiltration rates (Kauffman 2004).

Table 8-32 shows the primary limiting factors identified in the EDT Diagnostic Report for the Upper Mainstem John Day population. A summary of major limiting factors and threats is presented in Table 8-33.

Table 8-32. Limiting factors and priorities for protection and restoration as defined by EDT for the Upper Mainstem John Day River steelhead population.

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Beech Creek	○	○	●				●		●		●				●	●		●
Canyon Creek	○	○	●				●		●						●	●		●
Fields Creek	○	◯	●				●		●						●	●		●
JDR Johnson Creek									●						●	●		●
Laycock Creek	○	◯	●				●		●		●				●	●		●
Lower JDR Clarno									●					●				●
Lower JDR Ferry Canyon									●					●				●
Lower JDR Kahler Creek	○								●					●		●		●
Lower JDR McDonald Ferry	○								●					●				
Lower JDR Muddy Creek									●					●				●
Lower JDR Scott Canyon									●					●				●
Lower JDR Service Creek	○								●					●				●
Lower SF JDR									●						●			●
Rock Creek							●		●							●		●
Strawberry Creek	○	◯	●				●		●		●				●	●		●
Upper JDR	◯	○					●		●		●				●	●		●
Upper Middle JDR							●		●							●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

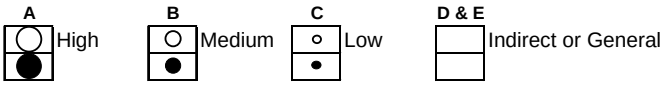


Table 8-33. Habitat limiting factors summary for the Upper Mainstem John Day River steelhead population.

Population MaSA and MiSA	Major Limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
UPPER MAINSTEM JOHN DAY POPULATION					
Upper Mainstem John Day Population	Degraded floodplain and channel structure (loss of cover, pools, LWD, overall habitat diversity, connectivity); water quality (temp);altered sediment routing; degraded riparian communities; altered hydrology; impaired fish passage	MaSAs and MiSAs	Productivity, abundance, spatial structure.	Agricultural practices, livestock grazing, removal of large trees from riparian corridor, wetland draining and conversion, stream channelization and diking, mining and dredging, irrigation withdrawals	Juvenile rearing, egg incubation, egg-to-parr survival, spawning
Up. John Day MaSA	Degraded floodplain and channel structure; altered hydrology; water quality (temp); altered sediment routing; degraded riparian communities; impaired passage	Mainstem and tribs [F,CS, S, H, T); Strawberry [H (lower), F,CS]; Pine [H (lower)}; Indian [H (lower)]; IP (pushup dam sites	Productivity, abundance, spatial structure.	Agricultural practices, livestock grazing, irrigation withdrawals, beaver removal, roads	Juvenile rearing, egg incubation, egg-to-parr survival, spawning
Beech MaSA	Degraded floodplain and channel structure; altered hydrology; water quality (temp); altered sediment routing; impaired passage	IP (Panama Ditch), F,CS (lower reaches, next to Hwy 395), H (lower reaches of Riley, Moon, McClellan, Laycock and Fields crs.); S,T	Productivity, abundance, spatial structure.	Hwy 395, forest roads, irrigation withdrawals, livestock grazing	Juvenile rearing, egg incubation, egg-to-parr survival, spawning
Canyon MaSA	Degraded floodplain and channel structure; altered hydrology; water quality (temp); altered sediment routing	F,CS (Hwy 395, forest roads), S,T,H	Productivity, abundance, spatial structure.	Hwy 395, forest roads, irrigation withdrawals, livestock grazing	Juvenile rearing, egg incubation, egg-to-parr survival, spawning

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F); degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.10 Umatilla River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for the Umatilla River steelhead population are water quality (temperature), sediment routing dysfunction, blocked and impaired fish passage, degraded floodplain and channel structure (key habitat quantity and habitat diversity) and hydrologic alterations.

Degraded floodplain connectivity and function

Intensive land uses within Umatilla subbasin flood plains and upslope habitats have led to dramatic changes in waterway characteristics since arrival of Euro-American pioneers to the area during the middle 1800's. Dikes, levies, and roads border many streams in the subbasin and limit connectivity between streams and their floodplains.

Degraded channel structure and connectivity

The mainstem Umatilla River from Wildhorse Creek to the forks and sections of 17 tributaries of the mainstem are 303(d) listed because of habitat (including substrate) problems. Habitat benchmarks developed by ODFW were used to list stream reaches based upon standardized habitat surveys (Moore et al.1999 cited in NPCC 2004c). Parameters measured in these surveys include habitat features known to be important to salmonids such as presence and amount of large woody debris, pool frequency, presence of eroding streambanks, type of riparian vegetation, stream channel form and pattern, and the proportion of the substrate composed of fine materials. Key habitat quantity and habitat diversity are also identified as medium impact limiting factors that are pervasive throughout the subbasin. Channel stability is frequently noted as a low impact limiting factor.

Overall, instream habitat has been simplified and pool habitat has decreased. Some stream reaches have been channelized in agricultural fields to prevent flooding of fields and natural channel movement into fields. Channelization greatly decreases winter habitat (e.g., braided channels, sloughs) for juvenile salmon and steelhead. This habitat is very important for overwinter survival and juvenile growth. The loss of this type of habitat in the Umatilla River and its tributaries is thought to be one of the most significant causes of the reduction in naturally surviving salmonid and steelhead (personal communication: C. Contor, CTUIR, April 2004 cited in NPCC 2004c). Other primary causes of low habitat diversity/complexity include past forest practices that removed conifers from riparian areas, and the ongoing removal of LWD from streams to prevent flooding and streambank erosion.

Altered sediment routing

The Umatilla River receives large amounts of sediment, much of which originates from weathered basalt and unconsolidated loess deposits — the dominant geology in the subbasin. Primary sources include bank and upland erosion of tributaries and tributary watersheds, which may be accelerated by land uses (ODEQ et al. 2001). Peak sedimentation usually occurs during rainstorms or snowmelts associated with freeze and thaw periods (CTUIR and ODFW 1990).

The entire Umatilla mainstem from the mouth to the forks is 303(d) listed for either sediment or turbidity. One sediment-impaired stream segment that significantly deviated from the target standard for turbidity was Wildhorse Creek (at its confluence with the Umatilla River) that had a peak turbidity value of over 5,000 nephelometric turbidity units (NTU) measured on April 23,1997. High levels were also measured in McKay Creek. Wildhorse Creek turbidity mainly results from spring runoff, while McKay's turbidity is mostly a result of bottom withdrawal of water from the reservoir for flow augmentation. Composite samples of turbidity, collected at various stations during the winter of 1997-1998, show that Tutuilla, Birch, and five sites on the Umatilla mainstem exceeded standards on numerous occasions (ODEQ et al. 2001).

Surveys conducted by ODFW and CTUIR throughout the Umatilla River subbasin found that 19 of 42 stream reaches had fine sediment as the dominant substrate (Boyd et al.1999 cited in NPCC 2004c). In the Patawa/Tutuilla watershed, fine sediment made up the dominant substrate in 9 of 19 reaches surveyed (Watershed Professionals and Duck Creek Associates 2003 cited in NPCC 2004c). Substrate sediment is less of a problem in the upper Umatilla subbasin; a survey of the upper Umatilla River and Meacham Creek by the Umatilla National Forest (2001) in

which substrate embeddedness was measured directly found that only two sub-watersheds of 18 had embeddedness levels greater than 35% (a level of embeddedness considered detrimental to salmon) (NPCC 2004c). EDT analyses also showed that sediment is a large limiting factor in many areas of the Umatilla, especially in Butter and Wildhorse creeks, in the lower reaches of the Umatilla, and in reaches of Umatilla mainstem from Mission Bridge to Meacham Creek.

Altered hydrologic processes

Flow patterns observed in the Umatilla/Willow subbasin are the result of snow melt and rain in late winter and early spring that cause peaks in flow. Water runoff peaks in April, while base flows generally occur in September. The average monthly discharge of the Umatilla River near its mouth (measured at RM 2.1) varies from 23 cfs in July to 1,095 cfs in April (low flow at the mouth occurs in July rather than September because of upstream removals for irrigation). Summer baseflows can be extremely low and many of the larger tributaries lose all surface flow during the summer through parts of their lengths. Flows in sections of Birch, McKay, Butter, Meacham, Wildhorse and Iskuulpa creeks are subsurface during low flow periods (ODEQ 1998 cited in NPCC 2004c).

Past evaluations of the Umatilla River have identified summer low flows as a primary limiting factor to salmonid natural production throughout all life stages (Boyce 1985, Contor et al. 1995, and CTUIR 1994 cited in White et al. 2004). EDT identifies flow as either a medium or low impact limiting factor in almost all reaches of the Umatilla subbasin.

Fluctuation of flows related to Umatilla Basin Project operations, for both the winter-spring storage and spring-fall release periods, is identified as a possible concern for juvenile steelhead and the food web on which they depend (BOR 2001). Significant fluctuations in flows on a weekly, daily, or even hourly basis may cause cyclic dewatering and rewatering of near shore habitats, riffles, and pools, which reduces biotic productivity and strands salmonid fry (BOR 2001), particularly in McKay Creek. Currently, there are six major irrigation diversions in the lower Umatilla River that withdraw approximately 129,000 acre-feet on an average year (Umatilla River Subbasin Local Agricultural Water Quality Advisory Committee et al. 1999). The irrigation withdrawals dewater the river below Dillon Dam, resulting in an average daily flow over a 14-day period of less than 1 cfs.

During late spring through late fall (April to November), water is released from McKay Reservoir to supply water for irrigation and instream uses. Summer discharge has more than tripled from RM 52.0 to 27.2 since the early 1900s; however, the river has been virtually de-watered from RM 27.2 to the confluence with the Columbia River (White et al. 2004). Streamflows below McKay Dam fluctuate greatly depending on flood water releases, irrigation releases, and other operations from McKay Reservoir (BOR 2001). BOR modeling results indicated that these water releases would increase Umatilla River flows. The model predicted that water releases in the late spring would aid juvenile steelhead in their out-migration, and that water releases in the summer and fall would aid juvenile summer rearing and adult upstream migration. The model also predicted that increased flows would connect pool and riffle habitat, increase the width and depth of flow, and improve velocity, water temperature, rearing space, and food production. Despite these predictions, however, actual July and August streamflows in the lower Umatilla River fall well below the recommended levels, with or without the operation

of the Umatilla Basin Project, and often dewater the lower three miles of the Umatilla River completely from July 1 to August 15. These conditions delay steelhead entry into the Umatilla Subbasin (BOR 2001; ODEQ et al. 2001).

Degraded water quality

Summer water temperatures in the lower Umatilla River frequently exceed the incipient lethal limit for salmonids of 21°C (ODEQ et al. 2001; White et al. 2004). Water temperature is a concern throughout most of the Umatilla subbasin during periods of low flow (May until early November). On the 1998 303(d) list, 287 miles of the Umatilla River and its tributaries were listed as impaired for elevated water temperatures including the entire mainstem Umatilla River (ODEQ et al. 2001 cited in NPCC 2004c) (Table 8-34). The highest water temperatures have been recorded in late July and early August when ambient air temperatures are high. During this period, the Umatilla River warms rapidly from the headwaters to the mouth, reaching sub-lethal (64-74°F, 20-23°C) and incipient lethal temperatures (70-77°F, 21-25°C) for its entire length (Boyd et al.1999; Contor and Crump 2003 cited in NPCC 2004c). White et al. (2004) noted that during 2002, mean weekly water temperature at RM 2.1 on the Umatilla River ranged from 39.2°F to 88.5°F. Daily mean water temperatures exceeded 75.2°F for 55 days in 2002, with 31 of those days at or above 82.0°F (White et al. 2004). Many of its tributaries also reach sub-lethal and incipient lethal ranges for salmonids (Boyd et al.1999; CTUIR 2004).

Water releases from McKay Reservoir during summer generally cool temperatures in reaches of the Umatilla River below the McKay Creek confluence (RM 50.5). Surveys determined that hypolimnetic releases of cool water from the reservoir during early summer months kept temperatures suitable for salmonids in areas between the McKay Creek confluence and Westland Dam (RM 27.2) (Contor et al.1997 cited in NPCC 2004c). However, releases from McKay Reservoir for fish are not made from July 1 to approximately September 15, though water is released to provide for irrigation. In addition, warmer epilimnetic waters can be discharged upon the depletion of the hypolimnion and can contribute to unsuitable habitat conditions for salmonids (Contor et al.1997 cited in NPCC 2004c).

The Umatilla subbasin's coolest mid-summer recorded temperatures are in the North Fork of the Umatilla River, where maximum summer temperatures usually do not exceed the state standard of 64°F (17.8°C). For example, in the summer of 2002, maximum water temperature in the North Fork did not exceed 60.8°F (16.0°C) (Contor and Crump 2003 cited in NPCC 2004c). The South Fork of the Umatilla River experiences higher summertime temperatures often above 64°F, though rarely above 70°F. Data indicate a significant increase (approximately 5° F) in temperature from the Umatilla River east of the Gibbon site (RM 80.0) to the Umatilla River at Cayuse Bridge (RM 69.4). This increase in temperature is attributed to Meacham Creek that enters the Umatilla Mainstem at RM 79. Summer water temperatures in Meacham Creek are frequently in the high 60s ºF. However, maximum summer temperatures drop further downstream (at RM 50) as a result of cold water releases from McKay Reservoir.

Wildhorse Creek is one of the warmest tributaries of the Umatilla River. This drainage regularly experiences excessive summertime stream temperatures throughout the entire stream length. Headwaters often exceed 70˚F for long periods in the summer, while lower Wildhorse Creek can often experience stream temperatures exceeding 85˚F.

The lower Umatilla River and the North Hermiston Drain are in violation of EPA ammonia standards, primarily because of excessive temperatures and pH during the summer months (ODEQ et al. 2001). Other problem areas include Butter Creek, where ammonia concentrations have been measured at 0.3 to greater than 0.4mg/L (ODEQ 1998).

Excessive growth of attached algae (periphyton) and attendant increases in pH are common during summer months throughout much of the mainstem Umatilla River (from Speare Canyon, RM 44, to the forks) (ODEQ et al. 2001). Large periphyton mats can be found in this section of the Umatilla River in the summer, affecting river odor, aesthetics, contact recreation, and pH. As periphyton obtains carbon dioxide for cell growth it decreases bicarbonate levels in the water. This has the effect of increasing pH levels that can be stressful to fish. Because periphyton growth is positively influenced by water temperature, patterns in summer water pH are influenced by water temperature. pH increases from the forks to RM 58, where it frequently exceeds 9.0 (the water quality standard); pH drops at RM 49 because of inputs of cold water from McKay Reservoir and then increases downstream where it routinely exceeds the water quality standard at Yoakum Bridge (RM 37.2)(ODEQ et al. 2001 cited in NPCC 2004c). Elevated summertime temperatures and excessive algal growth are also likely contributors to high pH levels recorded in Willow Creek, from the mouth upstream to Heppner.

Table 8-34. Impaired stream reaches from the 1998 303(d) list and used for development of the 2001 Umatilla Subbasin TMDL (ODEQ et al. 2001).

Parameter	Stream	Segment (boundaries)	Criterion
Temperature	Birch Creek	Mouth to headwaters	Rearing 64°F
	Buckaroo Creek	Mouth to headwaters	
	E. Birch Creek	Mouth to Pearson Creek	
	EF Meacham Creek	Mouth to headwaters	
	McKay Creek	Mouth to McKay Reservoir	
	Meacham Creek	Mouth to headwaters	
	NF McKay Creek	Mouth to headwaters	
	NF Meacham Creek	Mouth to headwaters	Oregon Bull Trout
	NF Umatilla River	Mouth to headwaters	
	Shimmiehorn Creek	Mouth to headwaters	
	SF Umatilla River	Mouth to headwaters	
	Squaw Creek	Mouth to headwaters	Rearing 64°F
	Umatilla R.	Mouth to Lick Creek	
	W. Birch Creek	Mouth to headwaters	
	Westgate Canyon	Mouth to headwaters	
	Wildhorse Creek	Mouth to headwaters	
Sediment	Beaver Creek	Mouth to headwaters	See Narrative
	Birch Creek, WF	Mouth to headwaters	
	Boston Canyon Creek	Mouth to headwaters	
	Coonskin Creek	Mouth to headwaters	
	Cottonwood Creek	Mouth to headwaters	
	Line Creek	Mouth to headwaters	
	Little Beaver Creek	Mouth to headwaters	
	Lost Pin Creek	Mouth to headwaters	
	McKay Creek, NF	Mouth to headwaters	
	Meacham Creek	East Meacham Creek to headwaters	
	Mill Creek	Mouth to headwaters	

Parameter	Stream	Segment (boundaries)	Criterion
	Mission Creek	Mouth to headwaters	
	Moonshine Creek	Mouth to headwaters	
	Rail Creek	Mouth to headwaters	
	Sheep Creek	Mouth to headwaters	
	Twomile Creek	Mouth to headwaters	
	Umatilla River	Wildhorse Creek to Forks	
Turbidity	Umatilla River	Mouth to Mission Creek	>30 NTU
pH	Umatilla River	Speare Canyon to Forks	pH 6.5-9.0
Nitrate	Wildhorse Creek	Mouth to headwaters	>10mg/L
	Spring Hollow Creek	Mouth to headwaters	
Ammonia	Umatilla River	Mouth to RM 5	pH dependent
	North Hermiston Drain	Mouth to headwaters	
Bacteria	McKay Creek	Mouth to McKay Reservoir	Water Contact Recreation (fecal coliform 96-Std)
	Umatilla River -- Summer	Mouth to Speare Canyon	
Aquatic Weeds/Algae	Umatilla River	Speare Canyon to Forks	Growth considered to be deleterious to aquatic, public, recreation, industry
Flow Modification	Birch Creek	Mouth to Headwaters	
	Umatilla River	Mouth to Speare Canyon	
Habitat Modification	Bell Cow Creek	Mouth to Headwaters	ODFW Habitat Benchmarks
	Boston Canyon Creek	Mouth to Speare Canyon	
	Calamity Creek	Mouth to Headwaters	
	Coonskin Creek	Mouth to Headwaters	
	Cottonwood Creek	Mouth to Headwaters	
	Darr Creek	Mouth to Headwaters	
	E. Birch Creek	Mouth to Headwaters	
	Line Creek	Mouth to Headwaters	
	Little Beaver Creek	Mouth to Headwaters	
	Lost Pin Creek	Mouth to Headwaters	
	Meacham Creek	Mouth to Headwaters	
	Mill Creek	Mouth to Headwaters	
	Mission Creek	Mouth to Headwaters	
	Moonshine Creek	Mouth to Headwaters	
	N.F. McKay Creek	Mouth to Headwaters	
	N.F. Meacham Creek	Mouth to Headwaters	
	Rail Creek	Mouth to Headwaters	
	Umatilla River	Mouth to Headwaters	
	Wood Hollow Creek	Mouth to Headwaters	

Blocked or impaired fish passage

In the Umatilla River subbasin, 36 barriers were identified in the Umatilla Subbasin Plan and these are listed in Table 8-35, along with their priority for removal. While it is not mentioned in the list, McKay Dam was not designed to include fish passage facilities, and blocks steelhead and salmon access to approximately 108 miles of highly productive tributary habitat in upper McKay Creek (CTUIR 2001). Historical abundance of steelhead in McKay Creek is unknown, but CTUIR tribal members report that a high number of steelhead spawned in McKay Creek before the construction of McKay Dam and Reservoir in 1927 (CTUIR 2001).

A number of significant passage barriers remain, particularly in Birch, and Butter creeks. Unscreened water diversions can also have a substantial impact on anadromous fish. All known gravity feed diversions in steelhead habitat areas of the Umatilla subbasin are screened, but it is not known to what extent pump diversions have been screened in the habitat areas.

Table 8-35. Barriers to upstream passage on streams in the Umatilla River Subbasin.

Stream	River Mile	Barrier Type	Step Height Est. (m)	Degree	Recommended Action	Priority
Umatilla R.	1.5	Channel Mod.	0.7	Partial	Modify	L
Umatilla R.	2.4	Irrigation Dam	1.0	Partial	Modify	M
Umatilla R.	49	Irrigation Dam	1.2	Partial	Remove	M
Butter Creek	7.9	Flash Boards	2.3	Complete	Modify	L
Butter Creek	27.2	Irrigation Dam	1.4	Complete	Modify	L
Butter Creek	43.0	Irrigation Dam	1.2	Complete	Modify	L
Johnson Cr. (Butter)	0.3	Culvert	0.8	Partial	Modify	M
Birch Creek	0.5	Pipe Casing	1.4	Partial	Modify	M
Birch Creek	2.5	Irrigation Dam	1.5	Partial	Modify/Remove	H
Birch Creek	5.0	Irrigation Dam	1.2	Partial	Modify/Remove	H
Birch Creek	10.0	Irrigation Dam	1.0	Partial	Remove	M
Birch Creek	11.0	Irrigation Dam	0.7	Partial	Remove	L
Birch Creek	12.0	Irrigation Dam	1.0	Partial	Modify	M
Birch Creek	15.0	Irrigation Dam	1.7	Partial	Remove	H
West Birch Cr.	1.0	Irrigation Dam	?	Partial	Modify	M
West Birch Cr.	3.5	Irrigation Dam	2.1	Partial	Modify	H
West Birch Cr.	3.8	Bridge	1.2	Partial	Modify	H
West Birch Cr.	5.5	Irrigation Dam	1.4	Partial	Remove	H
West Birch Cr.	8.5	Irrigation Dam	1.5	Partial	Remove	H
Bridge Cr. (W. Birch)	2.0	Culvert	?	Complete	Modify	H
East Birch Cr.	4.0	Irrigation Dam	0.7	Partial	Remove	L
East Birch Cr.	9.0	Irrigation Dam	1.0	Partial	Remove	L
Jungle/Windy Spr. (Pearson)	0.1	Culvert	0.15	Partial	Modify	L
Wildhorse Cr.	0.1	Irrigation Dam	0.7	Partial	Modify	L
Wildhorse Cr.	18.8	Bridge	1.0	Partial	Modify	L
Greasewood Cr.	0.4	Irrigation Dam	0.6	Partial	Modify	L
Mission Cr.	0.9	Bedrock Drop	0.5	Partial	Modify	M
Mission Cr.	3.3	Bridge/Culvert	0.7	Partial	Modify	M
Coonskin Cr.	0.3	Bridge	0.5	Partial	Modify	M
Coonskin Cr.	0.9	Pipe Casing	1.1	Partial	Modify	M
Whitman Spr.	0.1	Culvert	0.5	Complete	Modify	L
Red Elk Can.	0.2	Culvert	0.8	Partial	Modify	L
Minthorn Spr.	0.1	Culvert	0.5	Partial	Modify	L
Unnamed Trib to SF Umatilla at RM 1.5	0.1	Culvert	0.5	Complete	Modify	M
Camp Creek	0.25	Irrigation Dam	1.3	Partial	Remove	M
Unnamed trib to Umatilla R. at RM 81.2	0.1	Culvert	0.6	Partial	Modify	L
Twomile Creek	1.25	Culvert	?	?	Modify	L

Degraded riparian communities and large wood recruitment

Riparian vegetation on the mainstem Umatilla River and many tributaries is in poor condition, with 70% of 422 miles inventoried identified as needing riparian improvements (CTUIR and ODFW 1990 cited in NPCC 2004c). Losses of riparian vegetation are particularly high in the lower subbasin; Kagan et al. (2000) estimated these losses at greater than 95% as compared to pre-settlement conditions (c. 1850).

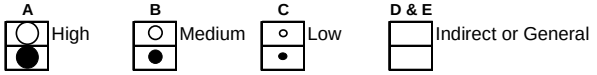
Table 8-36 shows key limiting factors for Mid-C steelhead in the Umatilla River drainage based on EDT findings. Table 8-37 summarizes major limiting factors and threats.

Table 8-36. Limiting factors and priorities for protection and restoration as defined by EDT for Umatilla River summer steelhead population.

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
GA1		○	●		●		●		●					●	⬤	⬤		●
GA2	○	○	●		●		●		●				●	●	⬤	●		
GA3			●				⬤		⬤						⬤			⬤
GA4		○	⬤				⬤		⬤	●					⬤	⬤		⬤
GA5		◯	⬤				⬤		⬤	●	⬤		●		⬤	⬤		⬤
GA6		○	●				⬤		⬤	●					⬤			⬤
GA7			⬤				●		●				●		⬤	⬤		⬤
GA8			⬤				●		●				●		⬤	⬤		⬤
GA9	○	○	●		●		●		⬤					●	●	●		
GA11			●		●		●		●					●	●	●		
GA12	○	◯	⬤				●		●		⬤		●		⬤	⬤		⬤
GA13		○	⬤				⬤		⬤	●	⬤		●		⬤	⬤		⬤
GA14	○	○	⬤				●		●						⬤	⬤		⬤
GA15	○	○	⬤				●		●		⬤				⬤	⬤		⬤
GA16			⬤				●		●							●		⬤
GA17		○	⬤				●		●	●					⬤	⬤		⬤
GA18	○	○	⬤				●		●						⬤	●		⬤
GA19	○	○	●				●		●							●		⬤
GA20		○	●				●		●	⬤				●	⬤	●		⬤
GA21		○	⬤				●		⬤		⬤		⬤	●	⬤	⬤		⬤
GA22			⬤				●		●				●			⬤		⬤
GA24			⬤				●		●							⬤		⬤
GA25			●		●		●		●					●	⬤	●		
GA26			●				●		●						⬤	⬤		●
GA27		○	⬤				⬤		●						⬤	⬤		●
GA28	○	◯	⬤		●		●		●				●	●	⬤	⬤		●
GA29		○	●				●		●				●		⬤	⬤		⬤
GA30			⬤				●	●	●							⬤		⬤
GA31		○	⬤				●	●							⬤	⬤		⬤
GA32		○	⬤				●	●	●						⬤	⬤		⬤
GA33	○	○	⬤		●		●	●	●					●		⬤		⬤
GA34	○	○	⬤		●		●		●					●	●			●
GA35	○	○	●		●		●		●		⬤			●		●		●
GA36	○	○	⬤		●		●		●					●		⬤		⬤
GA37	○		●		●		●		●					●				⬤
GA38		○	⬤		●		●		⬤					●	⬤			⬤
GA39			●		●		●				●			●	⬤			⬤
GA40	◯	○	⬤				●		●							⬤		●
GA41			⬤				●	●	●									⬤
GA42	◯	○	⬤															
GA43	○	○	⬤				●	●	●									
GA44	○		●				●											
GA45	○	○	⬤				●	●	●									⬤
GA46	○	○	⬤				●		●									

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Key to geographic areas: Planners identified the following geographic areas in the Umatilla subbasin as EDT geographic areas during the Northwest Power and Conservation Council's recent subbasin planning process (NPCC 2004c): GA1-2: Lower Umatilla, GA4-8: Butter Creek and tributaries, GA9-11: Mainstem Umatilla from Butter Creek to McKay Creek, GA12-19: Birch Creek and its tributaries, GA20-24: McKay Creek and its tributaries, GA25: Umatilla

mainstem from McKay Creek to Mission Bridge, GA26-27: Wildhorse Creek and its tributaries, GA28-32: Umatilla mainstem from Mission Bridge to Meacham Creek and its tributaries, GA33-37: Meacham Creek and its tributaries, GA40-41: Umatilla from Meacham Creek to the forks and its tributaries, GA42: North Fork Umatilla, GA43-46: South Fork Umatilla and various tributaries. The areas are also shown in Figure 8-2.

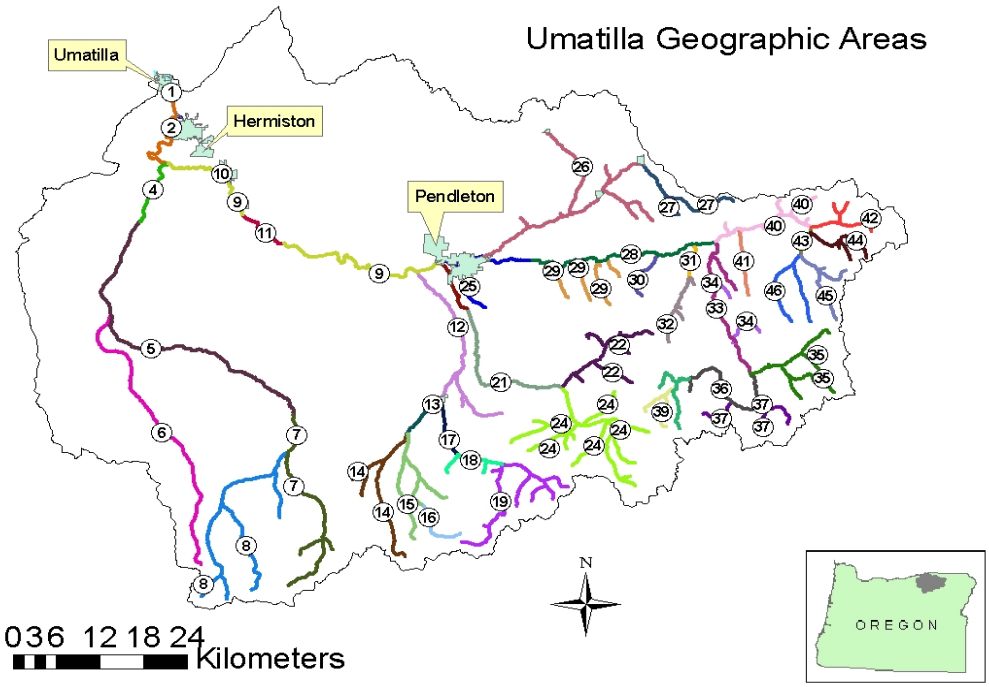


Figure 8-2. Geographic areas used in the EDT analysis for the Umatilla River Subbasin (NPCC 2004c).

Table 8-37. Habitat limiting factors summary for the Umatilla River steelhead population.

Population MaSA and MiSA	Major limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
UMATILLA RIVER POPULATION					
Umatilla River Population	Degraded floodplain and channel structure (complexity, diversity, braided channels, sloughs, pools); altered sediment routing; altered hydrology; water quality (temp, pH, ammonia, bacteria); blocked and impaired fish passage; degraded riparian communities, LWD recruitment	MaSAs and MiSAs	Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, flood control, forest practices, urban development	All life stages
Butter MaSA	Altered sediment routing; water quality (temp); altered hydrology; degraded floodplain and channel structure; blocked or impaired fish passage	Butter Cr. [BP (flash boards - RM 7.9, irrigation dams- RM 27.2 and 43)]; Johnson Cr. [IP (culvert RM 0.3)];	Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, urban development	All life stages
East Birch MaSA	Water quality (temp); altered sediment routing; degraded floodplain and channel structure; impaired fish passage	East Birch Cr. [T (mouth to Pearson C) and F, CS (mouth to headwaters); IP (irrigation dams RM 4.0, 9.0)]	Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, forest practices	All life stages
Little Butter MaSA	Altered sediment routing; degraded floodplain and channel structure; altered hydrology		Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion	All life stages
McKay MaSA	Degraded floodplain and channel structure; altered hydrology; water quality (temp, pathogens); altered sediment routing; impaired fish passage	McKay Cr. [T and B (mouth to reservoir), McKay Dam blocks steelhead access to 108 miles of productive habitat]; NF McKay [T,S, F, CS (mouth to headwaters)]	Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, urban development, forest practices	All life stages
Meacham MaSA	Water quality (temp); degraded floodplain and channel structure; impaired fish passage; altered sediment routing; altered hydrology	Meacham Cr. [T and F, CS (mouth to headwaters), S (above EF)] NF Meacham [T and F, CS (mouth to headwaters)]; EF Meacham [T (mouth to headwaters)]	Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion	All life stages
Middle Umatilla MaSA	Altered sediment routing; water quality (temp); degraded floodplain and channel structure; altered hydrology; degraded riparian communities		Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, Union Pacific railroad, roads, forest practices, flood control, urban development	All life stages

Population MaSA and MiSA	Major limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
UMATILLA RIVER POPULATION					
Upper Umatilla MaSA	Water quality (temp); degraded floodplain and channel structure (diversity/complexity); altered sediment routing; impaired fish passage		Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, Union Pacific railroad, roads, forest practices, flood control	All life stages
West Birch MaSA	Impaired fish passage; altered sediment routing; degraded floodplain and channel structure	West Birch Cr. [T and S (mouth to headwaters); IP (irrigation dams- RM 1, 3.5, 5.5, 8.5; bridge – RM 3.8)] Bridge Cr. [BP (culvert – RM 2)]	Abundance, productivity, spatial structure and diversity	Agricultural cultivation and practices, livestock grazing, water storage and diversion, forest practices	All life stages

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F); Degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.2.11 Walla Walla River Population, Tributary Habitat Limiting Factors

The primary tributary habitat limiting factors identified by the recovery planning team for the Walla Walla River steelhead population are water quality (temperature), altered sediment routing, blocked and impaired fish passage, degraded floodplain and channel structure (key habitat quantity and habitat diversity) and flow.

Degraded floodplain connectivity and function
Land use activities within the Walla Walla Subbasin including flood plains and upslopes have dramatically altered connectivity between the river channel and the floodplain. Dikes, levies, roads and channels exist throughout the subbasin and separate the channel from the floodplain.

Degraded channel structure and complexity
Habitat complexity is generally reduced or absent in the lower reaches of the Walla Walla River, particularly in channelized areas. Habitat complexity in headwater areas of some streams, including the South Fork, North Fork, and Mill Creek is close to or at properly functioning condition. The lower reaches of these tributaries, particularly in areas of agricultural or urban development, have poor habitat complexity due to a lack of pools and LWD.

Altered sediment routing
EDT analyses for streams occupied by this population indicate that elevated fine sediment levels in stream substrates are present, particularly in the lower reaches. Land management activities such as agriculture and road building add fine sediment to streams and reduced high flows can interrupt normal sediment flushing events.

Altered hydrologic processes
The runoff pattern in the Walla Walla River subbasin generally consists of high flows from November through May and low flows from June through October. The spring snowmelt flood period usually extends from about the first of March through the end of May, but peak discharges resulting from snowmelt runoff rarely result in damaging stages. In the past, winter flood peaks in the period of December through February have been responsible for flash-flood damage, caused by intense rainfall occurring on ground with high soil moisture content or by warm temperatures and rainfall on snow and frozen ground. (USACE 1997).

The Walla Walla River valley is extensively and intensively irrigated (NPCC 2004d). Primary water sources include the Touchet and Walla Walla rivers, East-West Canal, Gardena Canal, Lowden Canals, gravel aquifers, and the underlying basalt aquifer system (NPCC 2001, 2004d). Water diversions reduce flows in some reaches of the river and principle tributaries; lower Mill Creek and Walla Walla River near the border of Oregon and Washington have been completely dewatered in the past (NPCC 2004d). An increasing number of shallow individual domestic wells resulting from urban sprawl also pose a very real and significant deterrent to full utilization of the available water resources in the underlying aquifer (NPCC 2001, 2004d).

Degraded water quality
High water quality in the upper Walla Walla drainage generally degrades in lower elevations (NPCC 2001, 2004c). Temperature is a primary concern, with much of the lower Walla Walla remaining above 20°C (68°F) for most of the summer (NPCC 2001, 2004d). In Oregon, the Walla Walla River, North and South Forks of the Walla Walla River, and Mill Creek were all listed as 303(d) water quality limited for temperature in 2002 (ODEQ 2002). Sediment also reduces water quality as rain on frozen snow events in winter and spring often lead to high surface erosion in agricultural lands (NPCC 2001, 2004c).

Blocked or impaired fish passage
There are several total or partial fish passage barriers in the streams occupied by this population. Table 8-38 shows barriers to upstream passage in the subbasin for the Walla Walla steelhead population; however, the accuracy of the list is unknown because there has not been a comprehensive on-the-ground inventory of passage barriers in the subbasin. Obstructions are caused by low streamflow and channel spawning diversion structures and dams. Some culverts also act as fish passage barriers.

Table 8-38. Barriers to Upstream Passage on Streams in the Walla Walla Subbasin within the Area Inhabited by the Walla Walla River steelhead population. This list is based on a combination of archived records and field observation.

Stream	Description	River Mile /1	Priority	Lat.	Long.
Pine Cr.	Bevans Irrigation Dam	6.5	2	45.9903984	-118.57524108
Pine Cr.	Grade Control Structure on County Road 707	7.1	2	45.98669815	-118.56809997
Pine Cr.	Bevans and Young Irrigation Dam	7.5	2	45.98413848	-118.56359863
Pine Cr.	Irrigation Dam	8.1	2		
Pine Cr.	Irrigation Ditch Diversion	10.8	2		
Pine Cr.	Bridge on County Road 708	11.0	2	45.9595	-118.5372
Pine Cr.	Culvert at Johnson Road	23.6	2	45.8337	-118.4354
Pine Cr.	Culvert at Hwy 11	23.9	2	45.83039855	-118.43309783
Pine Cr.	Pine Cr. Rd Culvert	27	2	45.78490066	-118.40599822
Pine Cr.	Spring Reservoir Dam 1	28.7	2	45.77669906	-118.39499664
Pine Cr.	Spring Reservoir Dam 2	30.6	2	45.77603149	-118.36067962
Dry Cr.	Cockburn and Ray Irrigation Dam	1.0	2	45.9645195	-118.51821136
Dry Cr.	Marlatt-Shaw-Kelty Irrigation Dam	3.0	2	45.95537948	-118.48547363
Dry Cr.	Earnest Key Irrigation Dam	5.25	2	45.93603897	-118.45072174
Dry Cr.	Hohn and Phillips Irrigation Dam	5.75	2	45.93013	-118.44455718
Dry Cr.	Unnamed Dam	6.75	2	45.92193984	-118.43679809
Dry Cr.	Unnamed Dam	8.75	2	45.90356063	-118.41124725
Dry Cr.	Unnamed Dam	12.0	2	45.85702896	-118.40177154
Dry Cr.	Upper Dry Creek Rd Culvert	13.3	2	45.84577941	-118.38316345
Little Dry Cr.	Winn Rd Culvert	0.75	2	45.84624862	-118.4035263
Little Dry Cr.	Winn Power Dam	1.5	2	45.8399887	-118.40193176
Dry Cr. (Walla Walla)	Bridge at Lower Waitsburg Rd.	18.4	2		
Dry Cr. (Walla Walla)	Cement box culvert just upstream of Sapolil Rd.	24.1	2		
Mud Cr. (Dry Cr. Trib nr Dixie		1.4	2		
East Little Walla Walla	Locust Rd Culvert		2	45.95819854	-118.39649963
East Little Walla Walla	Appleton Rd Culvert		2	45.96920013	-118.40000152
East Little Walla Walla	Crockett Road Culvert		2	45.97299957	-118.39969635
East Little Walla Walla	Ballou Rd Culvert		2	45.98740005	-118.40440368
East Little Walla Walla	Stateline Rd Culvert		2	46.00040054	-118.4083023
West Little Walla Walla	Winesap Rd Culvert		2	45.96900177	-118.41320037
West Little Walla Walla	Appleton Rd Culvert		2	45.96920013	-118.41390228
West Little Walla Walla	Sunquist Rd Culvert		2	45.99110031	-118.42350006
West Little Walla Walla	Stateline Rd culvert		2	46.00049972	-118.43969726
Middle Branch Mud Cr.	Triangle Rd Culvert		2	45.97399902	-118.4287033
Middle Branch Mud Cr.	County Rd 332 Culvert		2	45.9748001	-118.43389892
Middle Branch Mud Cr.	County Rd 332 Culvert		2	45.97660064	-118.43779754
Mill Cr.	Stiller Ditch Diversion Dam	2.1	1		
Mill Cr.	Gose St. Dam and Concrete Apron	5.4	1		
Mill Cr.	Concrete Channel, velocity and light barriers	5.4 to 9.3	1		
Mill Cr.	Concrete capped weirs and diked channel from Gose St. to Bennington Dam	5.4 to 12.3	1		
Titus Cr.	Culvert at mouth	0	2		
Mill Cr.	Yellowhawk Division Dam and Ladder	11.4			

Stream	Description	River Mile /1	Priority	Lat.	Long.
Mill Cr.	Bennington Dam and ladder	12.3	1		
Mill Cr.	Kooskooskie Dam	23.0	1		
Mill Cr.	City Water Intake – fishway needs upgrading		1	45.99021148	-118.04837036
Garrison Cr.	Larch and Lyon's ponds	3.7	2		
Stone Cr.	Pond Dam	1.1	2		
Big Spring Cr.	Railroad crossing	0.7	2		
Unnamed spring	Railroad crossing	0.3	2		
Russell Cr.	Old irrigation diversion dam	0.9	2		
Russell Cr.	CCC Dam, complete obstruction	5.6	2		
Yellowhawk Cr.	Yellowhawk-Garrision Division Dam	7.8	1		
Doan Cr.	Underground pipe in which creek is confined	2.1	2		
Birch Cr.	Waterfall	0.4	1	45.99863815	-118.36891174
Birch Cr.	Culvert at Powerline Rd.	3.9	1	45.9824	-118.3139
Walla Walla R.	Nursery Bridge Dam – Additional improvements needed	46.8	1		
Couse Cr.	Culvert at gravel pit entrance	1.1	1	45.8967514	-118.36978149
Cup Gulch (NF Walla Walla	NF Walla Walla River Road Culvert		2	45.89690017	-118.25279998

Degraded riparian communities and large wood recruitment

Vegetative conditions in the Walla Walla subbasin reflect land use practices. Historically, extensive riparian zones existed along streams in the Walla Walla subbasin (USACE 1997). Along the Oregon portion of the river, 70% of the existing riparian zone is in poor condition (Water Resources Commission 1988 cited in USACE 1997). Where steppe grassland vegetation communities once existed in the valley, crops and invasive plant species have largely replaced them.

Table 8-39 shows key limiting factors for Mid-C steelhead in different parts of the Walla Walla drainage based on EDT findings. A summary of major limiting factors and threats is presented in Table 8-40.

Table 8-39. Limiting factors and priorities for protection and restoration as defined by EDT for the Walla Walla River steelhead population.

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Lower Walla Walla (mouth to Touche)		◯	●	•	●		●	•	●				●	●	●	●	•	•
Lower Touche (mouth to Coppei)			•		•		•		•					•	●	•	•	●
Walla Walla, Touche to Dry (plus Mud Cr)		○	•				●	•	●				●	•	●	●		●
Pine Cr mainstem (plus Swartz)		○	•				●		●		•		•		●	•		●
Dry Cr [Pine] Drainage		○	•		•		●	•	●	•			•		●	●		●
Lower Dry Cr (mouth to Sapolil)		○	•		•		●		●		●		•		●	●	•	•
Upper Dry Cr (Sapolil to forks)		○	•		•		•		•		●				●	●		•
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF Dry & SF D		○	●		•		●		●	•	●				●	●		•
Walla Walla, Dry to Mill		○	•		•		●		●	•			•	●	●	●	●	
W Little Walla Walla Drainage (plus Walsh)		○	•				●		●				•		●	●		●
Mill Cr, mouth to start of Corps Project at Gose St		○	•		•		●		●	•			•		●	●	•	●
Lower Mill Cr Tribs (Doan & Cold)		○	●				●		●	•	●				●	●	•	●
Mill Cr, Gose Street to Bennington Dam		◯	•		•		●	•	●	•	●		•		●	●		●
Mill Cr, Bennington Dam to Blue Cr (plusTitus)		○	•		•		●		●		●		•		●	●	•	●
Blue Cr Drainage (including L. Blue)			●				●		●				•		●	●		●
Mill Cr, Blue Cr to Walla Walla water intake	○	○	•				•		•						●	•		●
Middle Mill Cr Tribs (Henry Canyon, Webb &Tiger)			●				•		•									•
Mill Cr, Walla Walla water intake to access limit	○																	•
Upper Mill Tribs (NF, Low, Broken, Paradise)															•			●
Walla Walla, Mill to E L. Walla Walla (plus MacAvo		○	●				●		●	•			•		●	●		•
Garrison Cr Drainage (plus Bryant)		○	•		•		●	•	●	•	●		•		●	●		●
Stone Cr Drainage		○	●		•		●	•	●	●	●		•		●	●		●
E Little Walla Walla Drainage (plus Unnamed Sprin		○	•		•		●	•	●	•	•				●	•		●
Walla Walla, E Little Walla Walla to Tumalum Bridg	○	○	●				●		•	•					●	●		
Yellowhawk mainstem (mouth to source)		○	•		•		•		●	•			•		●	●		
Yellowhawk Tribs (Lassater, Russell, Reser & Cald		○	●				●		●	•	●				●	●		●
Cottonwood Cr Drainage (including NF, SF & MF)		○	●				●		●				•		●	●		●
Birch Creek Drainage			•				●	•	●	•	•		•		●	●		●
Walla Walla, Tumalum Bridge to Nursery Bridge		○	●				●	•	●	●					•	•		●
Walla Walla, Nursery Br to Little Walla Walla Diver		○	●				●	•	●	•					•			●
Walla Walla, Little Walla Walla Diversion to forks	○	○	•				•		●	•					•			●
Couse Creek Drainage			●				●		●	•		●	•		●	●		●
NF Walla Walla, mouth to L. Meadows Canyon Cr		○	●				●		●						●	●		●
NF Walla Walla, L. Meadows to access limit (plus E	○	○	●				•		•						•			
SF Walla Walla, mouth to Elbow Creek	○	◯	•				●		●						●	●		●
Lower SF Walla Walla Tribs (Flume Canyon, Elbow	○		●												●			●
SF Walla Walla, Elbow to access limit	◯	○																
Upper SF Walla Walla tribs (excluding Skiphorton &	○																	
Skiphorton & Reser Creek Drainages	○																	

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A ◯/● High B ○/● Medium C ○/• Low D & E Indirect or General

Table 8-40. Habitat limiting factors summary for the Walla Walla River steelhead population.

Population MaSA and MiSA	Major limiting Factors	Sites Affected*	VSP Characteristics Impacted	Threats	Life Stages Affected
WALLA WALLA RIVER POPULATION					
Walla Walla River Population	Degraded floodplain and channel structure (complexity, pools); altered sediment routing; altered hydrology; water quality (temp); blocked or impaired fish passage; degraded riparian communities	MaSAs and MiSAs	Abundance, productivity	Agricultural practices, water diversions for irrigation, wetland draining and conversion, urban development, stream channelization and diking	All life stages
Mill Creek MaSA	Impaired fish passage; altered sediment routing; water quality (temp); degraded floodplain and channel structure (pools, diversity, food, stability); degraded riparian communities	Mill Cr. [F,CS (LWD, pools – lower reach); T and H (lower reach)]	Abundance, productivity	Agriculture, urban development, flood control, water diversions	All life stages
Pine Creek MaSA	Altered sediment routing; degraded floodplain and channel structure (diversity, stability, food); altered hydrology; water quality (temp); impaired fish passage	Pine Cr. [many passage barriers; S (RM 1-5)]	Abundance, productivity		All life stages
Dry Creek MaSA	Altered hydrology; water quality (temp)		Abundance, productivity		Juvenile rearing, spawning
Cottonwood Creek MaSA	No data				
Walla Walla MaSA	Degraded floodplain and channel structure (diversity, quantity); altered hydrology; altered sediment routing; degraded riparian communities; water quality (temp); impaired fish passage	Walla Walla [T (lower)]; North Fork [F,CS, H,T, S and H (lower reach)]; South Fork [T, F,CS, H, S (lower reach)]	Abundance, productivity	Agricultural practices, livestock grazing, stream channelization,	All life stages

* Abbreviations for limiting factors: degraded floodplain connectivity and function (F); degraded channel structure and complexity (CS); degraded riparian communities (R); altered hydrology (H); degraded water quality (WQ), temperature (T); altered sediment routing (S); man-made block to migration (BP); impaired fish passage (IP).

8.3 Mainstem and Tributary Hydrosystems

This section describes direct and delayed effects of mainstem and tributary hydropower projects on Mid-C steelhead originating from the Fifteenmile Creek and the Deschutes, John Day, Umatilla and Walla Walla rivers. It describes how configurations and operations of the Federal Columbia River Power System affect the abundance and productivity of Mid-C steelhead juveniles and adults. This includes a discussion of how current actions under NOAA Fisheries 2004 FCRPS BiOp affect the juvenile and smolt-to-adult return of steelhead populations as well as factors related to species recovery. The section also discusses how tributary hydropower

projects in the Deschutes, Umatilla and Walla Walla rivers subbasins influence steelhead viability.

8.3.1 Mainstem Hydropower Configurations and Operations

The FCRPS consists of 19 sets of dams, powerhouses, and reservoirs, operated as a coordinated system for power production and flood control by the Federal Action Agencies (i.e., USACE, USBR, and BPA) under various Congressional authorities. The principle projects are: Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams, power plants, and reservoirs in the Snake River basin; Albeni Falls, Hungry Horse, Libby, Grand Coulee and Banks Lake (features of the Columbia Basin Project), and Chief Joseph dams, power plants, and reservoirs in the upper Columbia River basin; and McNary, John Day, The Dalles, and Bonneville dams, power plants, and reservoirs in the lower Columbia River basin.

Development and operation of the mainstem Columbia hydropower system dramatically alters travel conditions in the mainstem Columbia River, resulting in delayed upstream passage (adults), downstream passage (juveniles), and direct and indirect mortality for downstream migrants (juveniles). The hydropower system also changes the hydrograph; depleting historically available nutrients, increasing water temperatures, and degrading rearing and food resources for both presmolts and smolts in the Columbia River. Changes in the hydrograph leave steelhead more vulnerable to bird and pinniped predation in the mainstem and Columbia River estuary. These impacts increase somewhat for each population in direct relation to the number of dams that fish must pass during their migration to and from the Pacific Ocean. Mid-C steelhead populations pass one to four Columbia River dams: the Fifteenmile Creek population passes one dam; Deschutes River populations pass two dams; John Day River and Umatilla River populations pass three dams; and the Walla Walla River population passes four dams).

Legacy and Current Effects of Hydropower System
Hydropower development and operation in the Columbia Basin has reduced productivity, restricted salmonid migrations, altered habitats, and increased predation on and competition between juvenile salmonids. The hydropower system affects the following factors:

> **Loss of population traits and productivity:** Low adult abundance attributable to direct mortality of downstream migrant smolts at a dam, or to direct mortality or delayed passage of upstream migrant adults at a dam. Selective mortality resulting in non-normative changes in genetic and phenotypic characteristics. Reduction and possible elimination of iteroparity due to high mortality of kelts attempting to return to the ocean.
>
> **Impaired habitat access:** Impaired access to spawning and rearing areas upstream from a dam, or restriction of spawning and rearing to sub-optimal areas downstream from a dam.
>
> **Degraded habitat quality and quantity:** Modification of riverine habitat into impoundments results in changes in habitat availability, migration patterns, and feeding ecology. Downstream migration is significantly slower through impoundments. Food webs are different in the impoundments than in natural rivers.

Increased predation: Ecosystem alterations attributable to dams led to increased predation by native and introduced fish species on naturally produced juveniles. Other fishes, including northern pikeminnow, walleye, smallmouth bass, and salmonids, prey on juvenile salmonids. Modification of the Columbia River hydrosystem and estuarine habitat also led to increased predation by pinnipeds and birds on adult and juvenile salmonids.

Degraded water quality: Flow regulation and reservoir construction have increased average water temperatures beyond optimums for salmonids in the lower Columbia River. High water temperatures can cause migrating adult steelhead to stop or delay their migrations. Warm temperatures can also increase the fishes' susceptibility to disease. Flow regulation and reservoir construction also have increased water clarity that can affect salmonids through food availability and susceptibility to disease. Water can become supersaturated with atmospheric gases, primarily nitrogen, when water is spilled over high dams and this has resulted in significant salmonid mortality. Temperature changes influence physiological transition and seawater readiness of migrating smolts.

Altered hydrograph/water quantity: Changes in flow patterns affect steelhead migration and survival directly and indirectly. Juvenile and adult migration behavior and travel rates are related to river flow. Flow fluctuations stimulate or delay juvenile emigration or adult migration, thereby affecting the timing of juvenile arrival in the estuary and ocean, or adult arrival at the spawning grounds. Reduced springtime flows, for example, have delayed upstream migrations. Flow also affects the availability of habitat for mainstem spawning and rearing stocks. Rapid diurnal flow fluctuations can disrupt mainstem spawners, leave redds dewatered, or strand juveniles.

While management of the hydropower system has improved in recent years, the conditions created by current practices continue to exert negative impacts on the viability to Mid-C steelhead and other listed species today.

Current Effects of Federal Columbia River Power System Management

The FCRPS is currently operated consistent with actions identified in *NOAA Fisheries 2004 Federal Columbia River Power System Biological Opinion* (BiOp)(NOAA Fisheries 2004) and the U.S. Army Corps of Engineers *Final Updated Proposed Action for the FCRPS Biological Opinion Remand* (UPA) (USACE et al. 2004). These actions are intended to address the needs for survival and recovery of all ESA-listed salmon and steelhead ESUs and DPSs in the Columbia Basin. Operation of the FCRPS may change as a result of a remand of the NOAA Fisheries 2004 BiOp, as ordered in June 2005 by the Federal District Court. However, pending any court-ordered hydrosystem operational changes during the remand process, the FCRPS Action Agencies intend to implement the actions identified in the 2004 BiOp and UPA through 2014. Many of the actions are continuation of the 'Reasonable and Prudent Alternative' (RPA) actions contained in the 2000 Biological Opinion.

The following hydrosystem actions are currently being implemented under the 2004 BiOp and UPA.

Continue adult fish passage operations. The Action Agencies continue to complete capital construction projects at federal dams to improve adult fish passage. These fish passage improvements have resulted in meeting or exceeding the adult fish survival performance standards set out in the 2000 BiOp, however there is concern that they do not adequately address delayed mortality and reduced spawning success effects from upstream passage (delay/fallback). The effect of reduced operation of adult passage facilities during winter maintenance, which is especially critical for Fifteenmile Creek winter steelhead, is also a concern.

Improve juvenile fish passage. The Action Agencies continue to implement specific capital improvements, giving priority for funding and implementation to dams with the lowest juvenile passage survival rates. They are pursuing the use of removable spillway weirs (RSWs) or similar surface bypass devices, where feasible. RSWs are installed or planned for installation at all Snake River projects and feasibility studies are being conducted for RSWs at McNary and John Day dams and a forebay guidance device at The Dalles. These RSWs/surface bypass systems are currently designed to operate with reduced levels of conventional spill to provide similar or greater spillway passage and survival at a lower overall spill level to reduce operational costs. However, RSWs with greater training spill or multiple RSWs could be installed at projects to provide even higher spillway passage and survival.

Continue and enhance spill for juvenile fish passage. The basic spring and summer spill program from the 2004 BiOp continues to be implemented. Under the 2004 BiOp remand, court-ordered summer spill was provided in 2005 at Snake River collector projects and McNary Dam to improve survival of listed Snake River fall Chinook.

Continue reservoir operations and flow augmentation to benefit migrating fish. The Action Agencies continue to operate federal storage reservoirs to supplement streamflows and provide spill at mainstem dams to benefit juvenile fish migration consistent with current implementation of the 2000 BiOp as modified through implementation plans. The hydrosystem operations include both discretionary and nondiscretionary actions. Under these operations, the Action Agencies operate federal storage projects at or near upper (flood control) rule curve elevations during the spring to pass spring runoff downstream and to help refill the projects by July 1 for summer flow augmentation operations.

Modify fish transportation to improve juvenile survival. Collection and transport of juvenile fish at Lower Granite, Little Goose, Lower Monumental and McNary dams continues. Under the 2004 and previous Biological Opinions, spring migrants including Mid-C steelhead are not transported during the spring April 10-June 30 spill period so transportation effects (only potentially applicable to Yakima and Walla Walla steelhead) are not considered aside the effects of transportation of upriver stocks on straying in Middle Columbia tributaries.

While current actions under NOAA Fisheries 2004 BiOp are improvements over past hydropower system management, the FCRPS continues to affect Mid-C steelhead abundance and productivity by restricting migrations, altering habitats, and increasing predation on and competition between juvenile salmonids. As a result, the ICTRT ranked the Columbia hydropower system as a major limiting factor for all Oregon Mid-C steelhead populations. Effects of the FCRPS are assessed in the following four categories:

1. Smolt-to-adult returns
2. Juvenile migration and survival related to dam operations and river environment
3. Delayed mortality associated with the FCRPS
4. Adult migration and survival related to dam operations and river environment

Because of the lack of specific survival data for Mid-C steelhead, research data from juvenile steelhead marked primarily from Snake and upper Columbia River stocks, and run-at-large juvenile and adult fish were used to generalize effects of the FCRPS on Mid-C steelhead. These data gaps need to be addressed by the TRT.

1. Smolt-to-Adult Returns

Smolt-to-adult return (SAR) rates provide a measure of survival that encompasses smolt migration, estuary/ocean residence, and adult returns. Changes in SAR over a number of years provide an index of temporal variability in stock productivity and viability, and a basis to understand the relative effects of natural limiting factors in freshwater and marine environments, as well as effects of the FCRPS.

SAR data for hatchery and wild steelhead in the Umatilla and Hood rivers indicate that the effects of the FCRPS increase in relation to the number of dams the fish pass while migrating through the Columbia. Data for the Hood River, which is not part of the Mid-Columbia DPS, have been used here to represent fish passage through one mainstem dam, such as is true for Fifteenmile Creek. These data show that, although not directly comparable, survival of hatchery summer and winter steelhead released from the Hood River have about four to five-fold higher SARs (1.94 % summer and 1.65% winter for 1992-97 brood or 1994-99 migration years) than the Umatilla (0.39%). ODFW contends that that is likely due to additional mortality incurred from passage at three mainstem dams (John Day, The Dalles, and Bonneville) for Umatilla steelhead vs only one dam (Bonneville) for Hood River steelhead. Similarly, SARs of combined wild summer and winter steelhead in Hood River were about four-fold higher than SARs of wild summer steelhead in the Umatilla River.

For Umatilla River wild steelhead, SARs for 1995-2002 migration years ranged from 1.418% in 1996 to 5.316% in 1998, and averaged 2.570% for the eight-year period (Table 8-41).

Table 8-41. Smolt-to-adult return of Umatilla River wild summer steelhead at Three Mile Falls Dam for 1995-2002 migration years (White et al. 2007). Data are incomplete for 2001 and 2002 migration years.

Smolt Migration Year	No. of Smolts	No. Returns to TMFD	Smolt-to-Adult Return Rate (%)
1995	54,361	837	1.540
1996	73,361	1,040	1.418
1997	22,221	1,026	4.615
1998	59,182	3,146	5.316
1999	46,530	2,299	4.941
2000	81,759	4,045	4.948
2001	33,844	1,135	3.353
2002	77,016	1,649	2.141
2003	24,773		
2004	35,640		
2005	59,807		
Mean =	**51,681**		**2.570**

For hatchery summer steelhead released in the Umatilla River from 1987-97 broods, SARs have ranged from 0.043% for the 1988 brood to 0.752% for the 1994 brood and averaged 0.38% for the 11 years (Table 8-42).

Table 8-42. Smolt-to-adult return (hatchery release to Three Mile Falls Dam) of Umatilla Hatchery steelhead 1987-97 broods (Rowan 1998; Chess et al. 2005).

Brood Year	Rearing Location	No. CWT'ed	Total Released	Smolt-to-Adult Return Rate (%)	No. Adults Produced	No. Returns to TMFD
1987	Oak Springs Hatchery	58,067	61,306	0.437	374	268
1988	Oak Springs Hatchery	52,726	81,712	0.043	41	35
1989	Oak Springs Hatchery	56,034	89,193	0.704	838	628
1990	Oak Springs Hatchery	57,825	71,935	0.598	612	430
1991	Umatilla Hatchery	103,353	199,404	0.085	221	169
1992	Umatilla Hatchery	92,952	158,388	0.313	587	495
1993	Umatilla Hatchery	57,033	153,098	0.385	826	589
1994	Umatilla Hatchery	57,884	146,463	0.752	1372	1101
1995	Umatilla Hatchery	61,580	146,703	0.333	541	489
1996	Umatilla Hatchery	58,699	137,287	0.283	407	389
1997	Umatilla Hatchery	60,914	137,485	0.248	393	341
Mean =		**65,188**	**125,725**	**0.380**	**565**	**449**

For the Hood River, estimated SARs for combined wild summer and winter steelhead for 1994-2002 migration years ranged from 3.68% for 1997 migration year to 17.84% for 2001 and averaged 9.00% for the nine years (Table 8-43). Hatchery summer steelhead SARs for the same time period ranged from 0.98-4.52% with a mean of 2.51% (Table 8-44). Hatchery winter steelhead SARs for the same time period ranged from 0.64-2.90% with a mean of 1.78% (Table 8-45).

Table 8-43. Combined estimates of wild summer and winter steelhead subbasin smolt production, escapement to the mouth of the Hood River, and smolt-to-adult survival rate. Estimates are by year of migration. Year of migration is bold faced for those years in which estimates of adult escapements back to the mouth of the Hood River subbasin are greater than 97% complete (Olsen 2005).

Year of smolt migration	Smolts	Adult returns		Smolt-adult survival (%)
		Run years[a]	No.[b]	
1994	7,573	1994/95-1999/00	538	7.10
1995	4,656	1995/96-2000/01	438	9.41
1996	6,799	1996/97-2001/02	400	5.88
1997	13,334	1997/97-2001/02	400	3.68
1998	25,485	1998/99-2003/04	491	6.16
1999	18,842	1999/00-2004/05	1,569	8.22
2000	14,882	2000/01-2004/05	1,979	13.30
2001	5,786	2001/02-2004/05	1,032	17.84
2002	8,096	2002/03-2004/05	765	9.45

[a] Summer steelhead escapements in the 2004-2005 run year are preliminary estimates through 31 December, 2004. Winter steelhead returns are complete through the 2003-2004 run year.

[b] Hooking mortality was assumed to average approximately 10% in the sport fishery located from the mouth of the Hood River to Powerdale Dam.

Table 8-44. Estimates of Foster and Hood River stock hatchery summer steelhead subbasin smolt production releases, adult escapements to the mouth of the Hood River, smolt-to-adult survival rate, and percent difference from the wild smolt-to-adult survival rate. Estimates are by year of migration. Year of migration is bold faced for those years in which estimates of adult escapements back to the mouth of the Hood River subbasin are more than 97% complete (Olsen 2005).

	Foster stock hatchery summer steelhead					Hood River stock hatchery summer steelhead				
		Adult Returns		Smolt to adult survival			Adult Returns		Smolt-to-adult survival	
Year of smolt migration	Smolts[a,b]	Run Years[c]	No.	Percent Survival	Difference from wild (%)	Smolts[a,b]	Run Years[c]	No.	Percent Survival	Difference from wild (%)
1994	90,042	1995/96-2000/01	2,051	2.28	-67.89	--	--	--	--	--
1995	76,330	1996/97/2001/02	1,010	1.32	-85.97	--	--	--	--	--
1996	68,378	1997/98-2002/03	673	0.98	-83.33	--	--	--	--	--
1997	60,993	1998/99-2003/04	600	0.98	-73.37	--	--	--	--	--
1998	64,910	1999/00-2004/05	1,624	2.5	-59.42	--	--	--	--	--
1999	62,218	2000/01-2004/05	2,208	3.55	-56.81	19,513	2000/01-2003/04	470	2.41	-70.68
2000	49,278	2001/02-2004/05	2,225	4.52	-66.02	33,899	2001/02-2004/05	1,253	3.7	-72.18
2001	62,354	2002/03-2004/05	1,777	2.85	-84.02	37,665	2002/03-2004/05	522	1.39	-92.21
2002	58,711	2003/04-2004/05	2,100	3.58	-62.12	45,658	2003/04-2004/05	1,154	2.53	-73.23

[a] Production releases of Foster stock hatchery summer steelhead smolts were direct released into the West Fork of the Hood River from 1994-1997. Annual production releases were made below Powerdale Dam (RM 4.5) beginning in 1998.

[b] Number represents the estimated hatchery smolt production release. Numbers have not been adjusted for residualism.

[c] Escapements in the 2004-2005 run year are preliminary estimates through 9 March, 2005.

[d] Hood River stock hatchery summer steelhead smolts were first released into the Hood River subbasin in 1999 (1998 brood). The entire production release is acclimated for up to two weeks prior to being volitionally released into the West Fork of the Hood River.

[e] Hood River stock summer steelhead were generally not available for harvest in the sport fishery through the 2003-2004 run year; with the exception of a small number of adipose-left maxillary clipped adults returning from the 2000 brood release (i.e., 29 adults). This was because of their unique hatchery mark combination (i.e., maxillary only clip). The 2002 brood release was the first brood release in which the entire production group was marked with an adipose clip; in combination with another mark (i.e., a maxillary clip). Hooking mortality of maxillary only clipped adults was assumed to average approximately 10% in the sport fishery located from the mouth of the Hood River to Powerdale Dam.

[f] Estimates include counts at Powerdale Dam of adult steelhead with a valid (i.e., for harvest) Hood River stock summer steelhead mark combination that were classified as a Hood River stock (Unknown) winter steelhead.

Table 8-45. Estimates of Hood River stock hatchery winter steelhead subbasin smolt production releases, adult escapements to the mouth of the Hood River, smolt-to-adult survival rate, and percent difference from the wild smolt-to-adult survival rate. Estimates are by year of migration. Year of migration is bold faced for those years in which estimates of adult escapements back to the mouth of the Hood River subbasin are more than 97% complete (Olsen 2005).

		Adult returns		Smolt-adult survival	
Release strategy, year of smolt migration	Smolts[a,b]	Run years	No.[c]	Percent Survival	Diff. from wild (%)
Direct release,					
1994	38,034	1994/95-1998/99	682	1.79	-74.79
1995	4,656	1995/96-2000/01	1,023	2.39	-74.60
Acclimated,					
1996	6,799	1996/97-2001/02	580	1.14	-80.61
1997	13,334	1997/97-2001/02	385	0.64	-82.61
1998	25,485	1998/99-2003/04	651	1.05	-82.95
1999	18,842	1999/00-2004/05	1,355	2.90	-64.72
2000	14,882	2000/01-2004/05	1,724	2.73	-79.47
2001	5,786	2001/02-2004/05	720	1.42	-92.04
2002	8,096	2002/03-2004/05	1,220	1.94	-79.47

[a] Hood River stock hatchery winter steelhead smolts were first released into the Hood River subbasin in 1993 (1992 brood). The entire production release was first acclimated in 1996 (1995 brood). Hatchery smolts are acclimated for up to two weeks prior to being volitionally released into both the East and Middle forks of the Hood River.
[b] Number represents estimated smolt release. Numbers have not been adjusted for residualism.
[c] Number includes counts at Powerdale Dam of adult steelhead with a valid Hood River stock winter steelhead mark combination that were classified as a Hood River (Unknown) stock summer steelhead.

2. Juvenile Migration and Survival Related to Dam Operations and River Environment

Juvenile steelhead migration and survival are affected by dam operations (primarily spill), environmental parameters (primarily flow and temperature), and predation. Impacts on juvenile survival and migration timing are discussed below.

Juvenile survival

Currently, there are inadequate data to estimate juvenile survival of Mid-C steelhead because very few of these fish have been PIT-tagged, and only steelhead from the Umatilla and John Day rivers have been tagged. Consequently, data from PIT-tagged steelhead from the Snake River have been used to gain a better understanding of Mid-C steelhead survival through Mid-Columbia dams (McNary to Bonneville). While these findings cannot be directly extrapolated to Mid-C steelhead, they provide a basis for understanding probable environmental and dam operational conditions that might be influencing survival and viability of Mid-C steelhead. Additional tagging of specific Mid-C stocks is needed to corroborate results.

Data collected by the Fish Passage Center (FPC 2005) from 1999 to 2005 show statistically significant relationships between survival of PIT tagged steelhead from McNary to Bonneville dams and spill (Figure 8-3), water transit time (related to flow) (Figure 8-4), and temperature (Figure 8-5). Pearson's correlation matrix for these analyses is provided in Table 8-46. Although these relationships were highly influenced by a single low flow year (2001), they still suggest that survival of steelhead is influenced by the amount of spill, flow, and temperature at Mid-Columbia dams, with higher survival at higher spill and flow and lower water temperatures. These results are similar to those found for yearling Chinook between McNary to Bonneville (FPC 2005), and for yearling Chinook and steelhead between Lower Granite to McNary dams.

(FPC 2005) where greater sample sizes and observations over a wider range of dam operations and environmental conditions allow greater statistical rigor and strength of relationships.

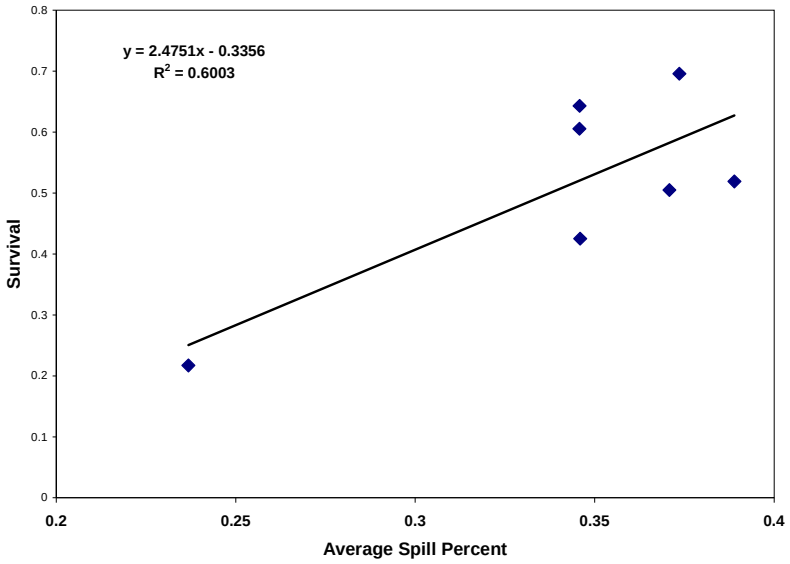


Figure 8-3. Reach survival from McNary Dam to Bonneville Dam for PIT-tagged steelhead detected at McNary Dam between May 11 and June 8 for years 1999 to 2005 plotted with average spill percent at John Day, The Dalles and Bonneville dams.

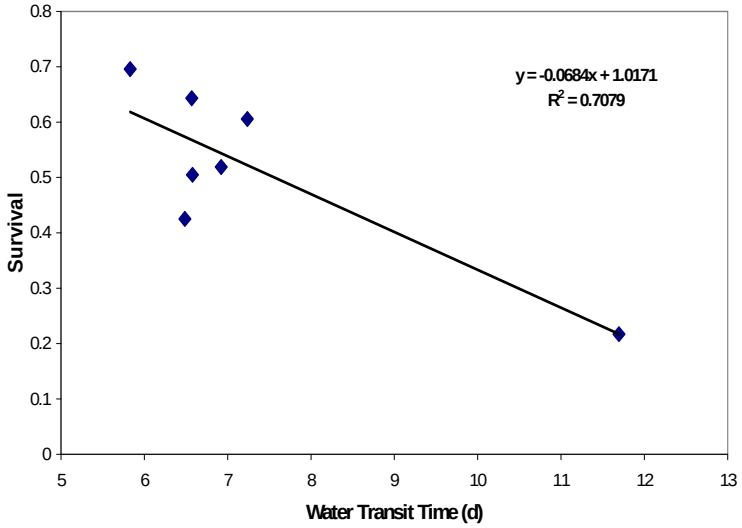


Figure 8-4. Reach survival from McNary Dam to Bonneville Dam for PIT-tagged steelhead detected at McNary Dam between May 11 and June 8 for years 1999 to 2005 plotted with average water transit time for the reach McNary Dam to Bonneville Dam.

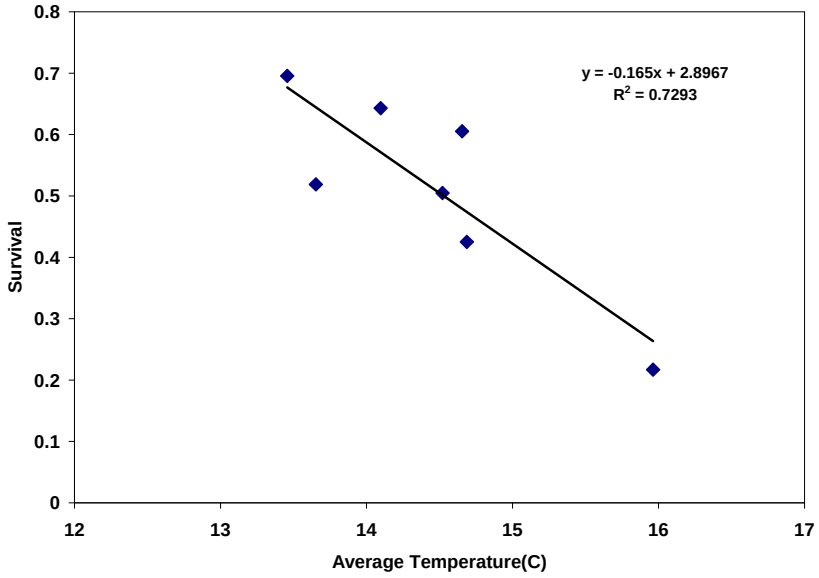


Figure 8-5. Reach survival from McNary Dam to Bonneville Dam for PIT-tagged steelhead detected at McNary Dam between May 11 and June 8 for years 1999 to 2005 plotted with average water temperature(C) measured at tailwater TDGS monitors for the reach McNary Dam to Bonneville Dam.

Table 8-46. Pearson correlation matrix for Snake River steelhead survival relationships.

	SURVIVAL	TRAVTIME	WTT	AVGSPILL	AVTEMP
SURVIVAL	1.00000				
TRAVTIME	-0.76894	1.00000			
WTT	-0.84138	0.96015	1.00000		
AVGSPILL	0.77482	-0.92923	-0.93281	1.00000	
AVTEMP	-0.85401	0.87935	0.85638	-0.90103	1.00000

Data from PIT-tagged steelhead from the Snake River have been used to estimate survival through Mid-Columbia dams. These data were not sufficient to estimate juvenile steelhead survival from McNary to Bonneville until 1997, and then only for pooled wild and hatchery steelhead (Table 8-47). Annual estimates ranged from 0.250 in 2001 to 0.770 in 1998, and averaged 0.540 for the seven years. These survival estimates include only direct effects of passage through the Mid-Columbia dams and reservoirs; delayed, or latent, mortality from hydrosystem passage for these fish is discussed later in this section.

Data from 1997 to 2003 indicate that steelhead survival from McNary Dam to Bonneville Dam is influenced by dam operations (spill); as well as migration rate (as influenced by flow), temperature, and predation. Survival in 2001 was only about one-third of 1998, due to extremely

low flows, high temperatures, and limited spill at each dam because of a declared power emergency by BPA (Williams et al. 2005).

Table 8-47. Estimated survival from McNary Dam tailrace to Bonneville Dam tailrace for hatchery and wild steelhead (pooled) PIT tagged from the Snake River (from Williams et al. 2005).

Year	Survival	Standard Error
1997	0.651	0.082
1998	0.770	0.081
1999	0.640	0.024
2000	0.580	0.047
2001	0.250	0.016
2002	0.488	0.090
2003	0.510	0.015
Average	0.540	0.071

Survival data from 1999 to 2005 for wild summer steelhead from release in the Umatilla River to John Day Dam echo these findings. Results from these data — which examine effects in the Umatilla River and also passage through John Day Reservoir — show that survival probabilities were lowest in 2001 and 2004, two below normal flow years in both the Umatilla and Columbia rivers (Table 8-48).

Table 8-48. SURPH generated survival and capture probabilities for natural summer steelhead tagged and released into the Umatilla River, 1999 – 2005 (White et al. 2007). S*P = Survival Probability.

	Survival probabilities			Capture probabilities		Final S*P		
Year	TMFD	TMFD to JDD	JDD	TMFD	JDD	TMFD	JDD	Number tagged
				All fish tagged and released in Upper Basin[a]				
1999	0.26	0.75	0.19	0.32	0.42	0.40	0.19	2010
2000	0.34	0.52	0.18	0.34	0.34	0.25	0.22	1652
2001	0.39	0.38	0.15	0.15	0.53	0.27	0.36	2622
				Fish tagged and released from January - June in Upper Basin[ab]				
2000	0.37	0.57	0.21	0.36	0.29	0.24	0.18	1281
2001	0.40	0.37	0.15	0.15	0.53	0.26	0.36	2480
				Fish tagged at TMFD for Trap Efficiency tests[c]				
1999	0.97	0.69	0.67	0.21	0.37		0.20	1845
2000	--	--	--	--	--	--	--	24
2001	0.75	0.53	0.40	0.35	0.25		0.21	281
2002	1.04	0.61	0.64	0.17	0.30		0.14	468
2003	0.80	0.64	0.51	0.18	0.40		0.32	498
2004	0.84	0.44	0.37	0.43	0.39		0.13	309
2005	0.91	0.54	0.49	0.29	0.41		0.10	704

[a] These fish were tagged at various times and released at various upriver sites (RM 48 – RM 80) but were grouped for species survival. Natural fish were only tagged from 1999 to 2001.

[b] Fish tagged from January to June were assumed to be actively migrating smolts. These fish were separated because of the potential for overwintering mortality associated with fish tagged from July to December.

[c] These fish were released about 1.5 miles upstream of TMFD at various times.

Predation by Piscivorous Fish. Survival rates also reflect predation that has increased due to dam development and operations. Slower river flows and warmer water temperatures in the lower Columbia River caused by hydropower development and operations create hospitable environments for northern pikeminnow, walleye, smallmouth bass and other fishes that prey on outmigrating juvenile steelhead. The dams can stress and disorient migrating smolts, making them vulnerable to predators. Dams may also delay migration, thereby increasing travel time and exposure to predators. Northern pikeminnow are considered the major piscivore responsible for predation on juvenile salmonids, with mortality potentially similar to that caused by dam passage (Rieman et al. 1991). Predation impacts are further discussed in Sections 8.7.

Juvenile migration timing

Data on the migration timing for wild Mid-C steelhead in the mainstem Columbia River, as determined by detection of PIT tagged fish, are limited to wild and hatchery steelhead PIT tagged in the Umatilla River, where adequate numbers have been PIT tagged since 2001. PIT tagging of wild steelhead has also been initiated in the John Day, Wind and Hood rivers, but inadequate numbers have been detected at mainstem dams to determine migration timing.

Summarized migration timing data for Umatilla River wild and hatchery PIT tagged steelhead from 2001 to 2005 show that Umatilla steelhead generally passed John Day Dam during April and May, typical of migration timing of steelhead PIT tagged in the Snake and upper Columbia rivers (Figures 8-6--8-10). However, in 2001, Umatilla steelhead migrations extended into August because of drought and power emergency (limited spill) conditions (Figure 8-6).

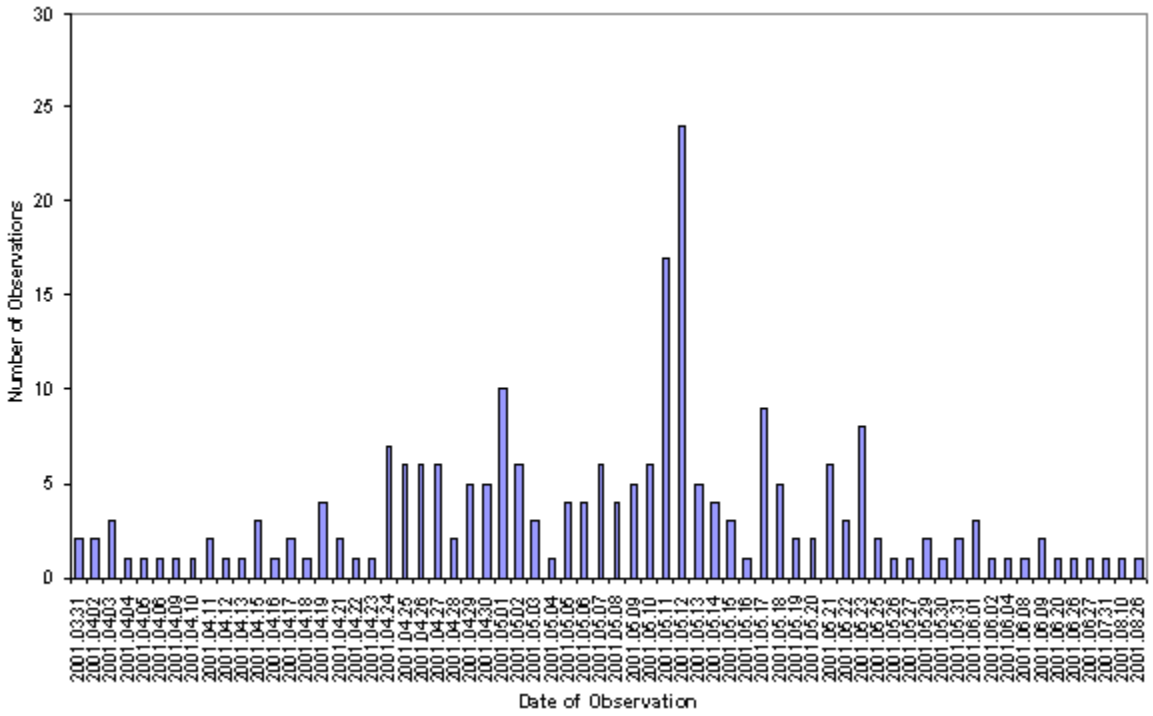


Figure 8-6. Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2001.

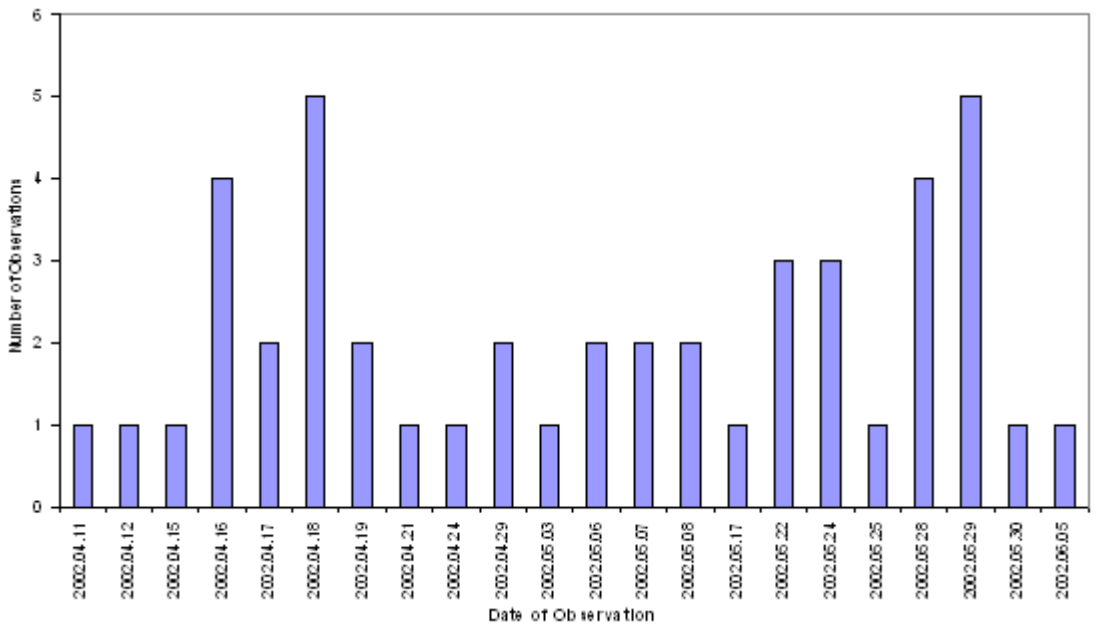


Figure 8-7. Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2002.

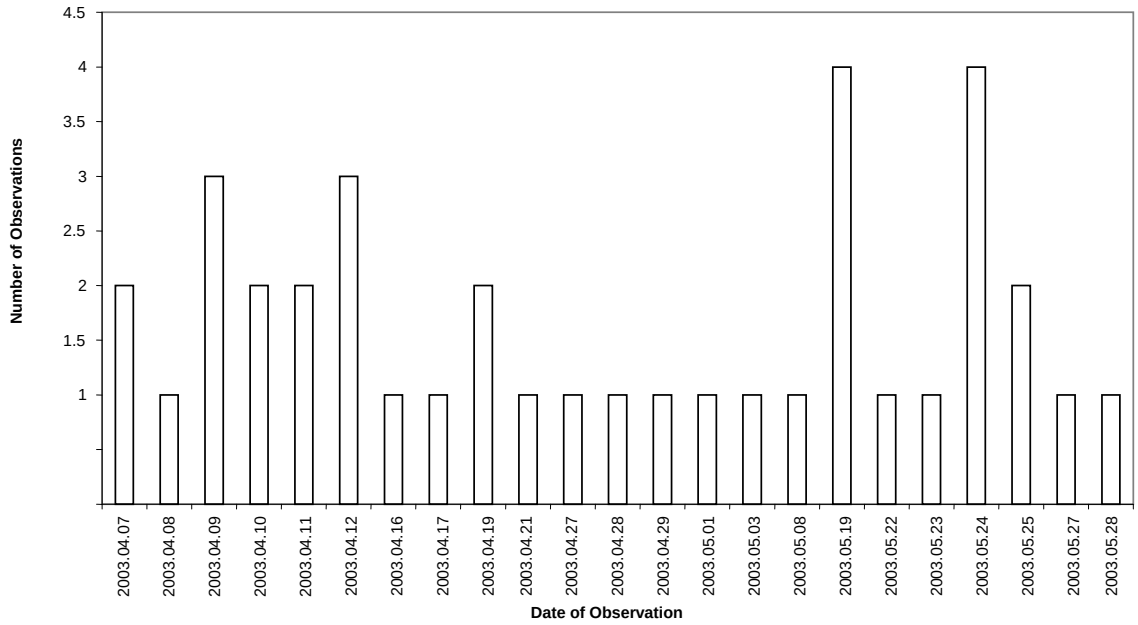


Figure 8-8. Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2003.

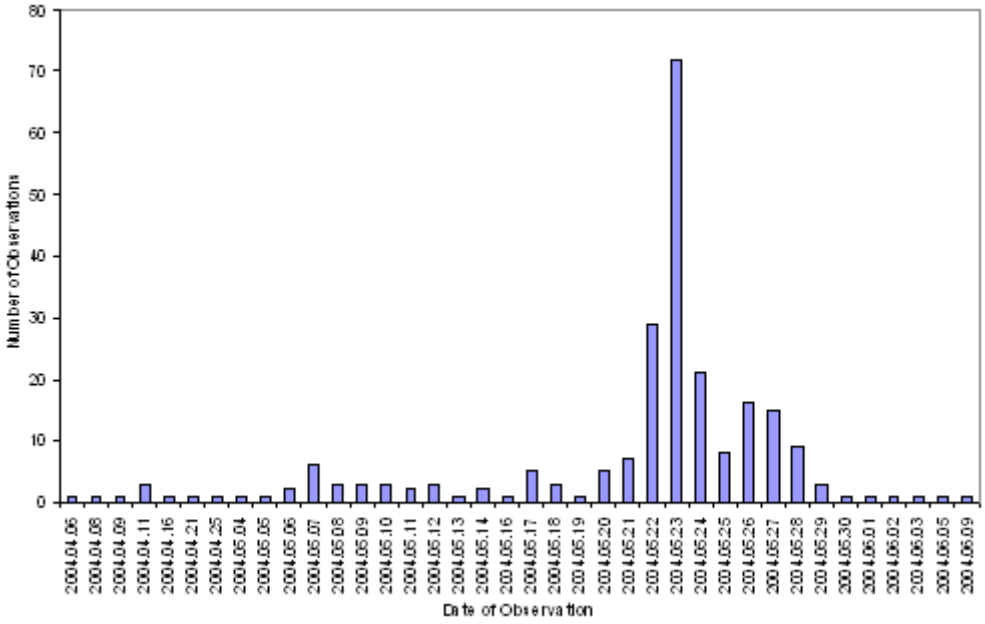


Figure 8-9. Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2004.

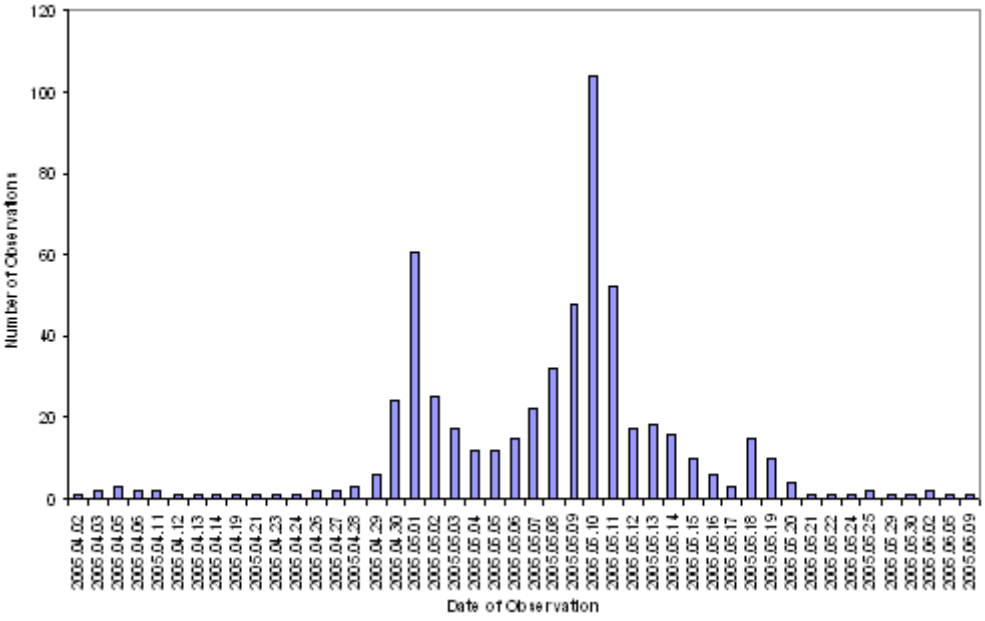


Figure 8-10. Migration timing of wild PIT-tagged Umatilla River steelhead at John Day Dam in 2005.

3. Delayed Mortality Associated with the FCRPS

While there currently is not enough data to determine what level of latent mortality for Mid-C steelhead can be attributed to passage through the hydropower system, studies and analyses conducted on Snake River spring/summer Chinook and steelhead indicate that latent mortality can be high. Comparisons of SARs for Snake River spring/summer Chinook and steelhead with survival estimates through the FCRPS (both juvenile downstream and adult upstream direct survival estimates) indicate that most mortality of both in-river and transported fish occurs outside the hydrosystem, manifested as "delayed" mortality (Marmorek et al. 2004). Studies and analyses have been conducted over the last 10 years to identify causative mechanisms including changes in migration timing (from delay of in-river smolts and acceleration of transported smolts), disease transmission or stress resulting from concentration of fish in bypass/transportation facilities, depletion of energy reserves due to prolonged migrations, altered estuary/plume characteristics, and disruption of homing instincts.

The Comparative Survival Study (CSS) Workshop (Marmorek et al. 2004) found that results from updated modeling (Delta model used by Deriso et al. 2001) indicate that delayed mortality for Snake River spring/summer Chinook has remained high in recent years (long-term average=0.81) despite improvements in ocean conditions. The CSS Workshop evaluated evidence of several mechanisms of delayed mortality, including several that are directly applicable to Mid-C steelhead:

The hydrosystem indirectly affects SARs by delaying in-river arrival of smolts in the estuary- Snake River steelhead arrive in the estuary 2-3 weeks later than historically (travel times greatly extended due to reduced water particle time from dam construction) that influence availability of prey that might be key in estuary/early ocean survival. Although delay of Mid-C steelhead may not be as great as Snake River stocks, any delay may affect survival.

The hydrosystem indirectly affects SARs by delaying the smolt development process through altered entry timing and stress- Similar to Snake River stocks, Mid-C steelhead may be stressed from hydrosystem passage and reverse in smolt development decreasing overall survival.

The hydrosystem indirectly affects SARs through size selectivity and annual variation in bypass survival- Although thought to be a key hypothesis (Williams et al. 2005), a re-analysis of data by Marmorek et al. (2004) for Snake River wild Chinook showed a weak trend in size selectivity and only at Little Goose Dam. Bypass passage for Mid-C steelhead is probably less of a factor than for upriver stocks due to less bypass systems encountered (most stocks are affected by only two dams, John Day and Bonneville, as there is no bypass at The Dalles).

Smolt passage through the hydrosystem increases stress, reduces growth rate and fish condition that increases vulnerability to mortality factors including predation and horizontal transmission of pathogens- This hypothesis is likely but uncertain as evidence is mainly from laboratory studies and lack of empirical data confirming results.

4. Adult Migration and Survival Related to Dam Operations and River Environment

Research by the University of Idaho and NMFS since 1996 (provided by Dr. Chris Peery, University of Idaho) indicates that adult steelhead migration and survival is also affected by the FCRPS. The research focused primarily on passage of adult Snake River salmon and steelhead, but the findings are also applicable, though to a lesser degree, to Mid-C steelhead.

From 1996 to 2003, more than 18,000 adult Snake River salmon and steelhead, were radio-tagged and monitored, and the fates of individual fish were assessed. Monitored groups included spring, summer, and fall Chinook salmon, steelhead, and sockeye salmon. Samples from later years included adults that were PIT-tagged as juveniles at known locations, allowing researchers to assess behavior and survival for individuals with known homing destinations. The tagging program has included several ESA-listed stocks including limited Mid-C steelhead (primarily Umatilla and John Day steelhead). Additional information related to research results described here can be found at, http://www.cnr.uidaho.edu/uiferl/.

Survival and pre-spawn mortality

Survival. Survival through the Columbia River hydrosystem (Bonneville Dam to Lower Granite or Priest Rapids dams) averaged 73% for spring–summer Chinook salmon, 61% for fall Chinook salmon, and 63% for steelhead; survival varied significantly among years (Figure 8-11). Fish that did not reach spawning areas were presumed lost to harvest and other causes. Survival of Mid-C steelhead is likely to be higher due to less dams encountered.

Non-Harvest Mortality. After accounting for fishing mortality, an average of 12–17% of Columbia River and Snake River salmon and steelhead adults had unknown fates before reaching spawning tributaries or exiting the monitored hydrosystem. Causes for these mortalities are unknown, but likely include extended migrations, stress from elevated water temperatures, energetic exhaustion, disease, unreported harvest, delayed mortality due to injuries sustained during fallback or from encounters with fisheries, or other factors. An important finding applicable to Mid-C steelhead is that survival for all runs has tended to be lowest in the lower Columbia River (Bonneville to McNary) and higher through lower Snake River reaches.

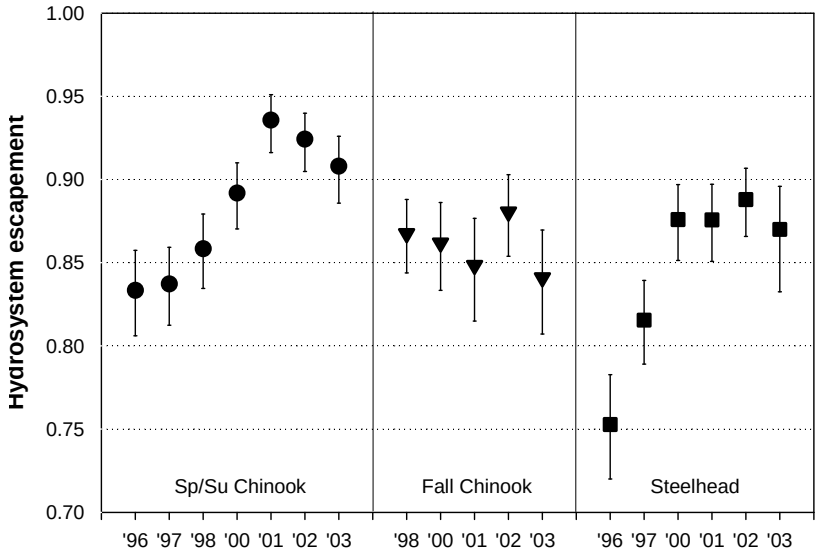


Figure 8-11. Average escapement for adult spring/summer Chinook salmon, fall Chinook salmon, and steelhead through the Federal Columbia River Power System, adjusted for known commercial and sport harvests. Error bars are 95% CIs.

Pinniped Predation. Predation by Pacific harbor seals, Steller sea lions and California sea lions on salmon and steelhead in the lower Columbia River has increased in recent years. More and more seal lions have been traveling as far as Bonneville Dam to prey on adult salmon and steelhead that congregate below the dam before attempting to climb the fish ladders. They also consume large numbers of salmon and steelhead in the 145 miles of the Columbia River below the dam. Section 8.7 discusses the effects of pinniped predation on Mid-C steelhead.

Pre-Spawn Mortality. Additional mortality occurs upstream from the hydrosystem and before spawning, but quantitative summaries of these components of adult survival are limited. Intensive surveys of spawning areas in the South Fork Salmon River, Idaho, reveal 25 to 60% of successful Chinook salmon migrants die before spawning each year compared to numbers observed at Lower Granite. A study is underway to determine how migration history, water temperatures in and upstream from the hydrosystem, and fish energetics are related to pre-spawn mortality for this population. Similar studies are needed for Mid-C steelhead.

Straying. Permanent inter-basin straying is a challenging component of assessing adult survival because they could be considered either successful migrants (they reached a spawning area) or unsuccessful migrants (they did not home to their natal site). On average, 2–4% of known-origin spring–summer and fall Chinook salmon and 7% of steelhead in the radiotelemetry study strayed into non-natal basins where they may have spawned with native stocks. Hatchery fish and fish transported (barged) from the Snake River as juveniles were more likely than other groups to stray. Many stray steelhead from the Snake River entered the Deschutes and John Day rivers and possibly spawn with native populations.

Wandering. In warm years and during warm periods within years, large proportions of summer and fall Chinook salmon and steelhead runs encounter temperatures considered stressful for salmonids. In response, many fish seek cool thermal refuges—and particularly cool non-natal tributary streams particularly the Deschutes River. During the warmest times, majorities of the fall Chinook and steelhead runs concentrate in these refugia, where they may be highly vulnerable to harvest. While the behavior likely has immediate energetic benefits, delays and elevated harvest risks during warm water periods may lead to overall decreases in system productivity. There is some evidence that survival consequences of high temperature exposure may be greater for obligatory migrants like Chinook salmon than for steelhead which migrate many months in advance of spawning.

Effects of dams and operations

Passage Rates. Most adult salmon and steelhead pass individual dams in 1 to 2 days, and pass quickly through reservoirs. However, a proportion of each run (typically between 2–12%) takes several days to weeks to pass individual dams. Research found that fish that took a relatively long time to pass individual dams were less likely to migrate successfully to spawning tributaries. Similarly, relatively slow passage through the lower Columbia hydrosystem (multiple dams and reservoirs) from McNary to Bonneville was associated with unsuccessful migration. Though the cause is unknown, the association described above may have resulted from inadequate dam passage facilities 'delaying' some individuals, the expenditure of large amounts of energetic stores, and resulting in premature death. Alternatively, individuals in poor condition at river-entry may have been both slow and less likely to reach spawning grounds, regardless of passage conditions at dams. Studies are on-going to determine the relative roles of these two mechanisms. Improving passage efficiency has been a management goal, and incremental improvements to fishways (transition pools, count windows, entrance and exit conditions) and operations (spill, fishway temperatures) are being studied and implemented.

Fallback. Some fish from all runs pass dams and then fall back downstream. Approximately 22% of spring/summer Chinook salmon, 15% of fall Chinook salmon, and 21% of steelhead fell back at one or more dams during migration. Fallback is associated with both direct and delayed mortality, slowed migration rates, and increased likelihood of straying. Fallback rates have been highest in years with high river flow and high spill at dams, at least in part because most fish fall back via dam spillways. Fish also appear to fall back as a result of orientation errors, including failure to locate natal tributaries and imprinting problems associated with juvenile barging. Providing benign downstream passage routes for these individuals could lessen the survival costs of fallback. Operational changes may help reduce fallback and therefore increase overall survival, but it is unclear how large a reduction is possible given the management constraints.

Juvenile Barging. Currently, about 70% of juvenile migrating seaward in the Snake River are collected and transported by barge below Bonneville Dam. Returning adults that had been barged as juveniles were ~10% less likely to migrate to spawning grounds, exhibited less direct migrations, and strayed to non-natal tributaries (ex: Deschutes River) at rates that were approximately twice that of adults that had migrated in the river as juveniles. Barging probably interrupts the 'sequential imprinting' process whereby adults use olfactory memories from the juvenile seaward migration during homing. It should be noted that fish used in this study are captured at the Washington shore fish trap which may have influenced results.

Spill. Results three years when spill levels were manipulated at Bonneville Dam suggest that high spill volumes (>100 to kcfs at Bonneville) increase adult passage times slightly compared to moderate spill volumes of ~75 kcfs. Higher spill was also associated with higher fallback rates in spring Chinook salmon and in steelhead. As already noted, longer passage times and fallback events have been associated with lower survival for individual fish.

Summer Spill. Preliminary results from the adult radiotelemetry project suggest that moderate spill during summer would likely have only a limited impact on adult passage. Summer Chinook salmon also exhibited slight increases in passage time and fallback rate at high spill levels at Bonneville dam. However, these effects should be weighted against the potential benefits of limited spill for those adults that volitionally fallback (i.e., those that overshot natal tributaries) because fallback via spillways is more benign than through turbines.

Fishway Temperatures. Elevated water temperatures and large temperature differentials (between the top and bottom of ladders) in dam fishways can deter passage. Mean passage times for spring-summer Chinook at Lower Granite Dam increased from 6.6 hours when temperatures at the ladder exit were similar to those at the base of the ladder, to 19.1 hours when exit temperatures were ≥ 2˚C warmer than at the base. Similarly, the proportion of fish requiring more than one day to pass the dam increased from 32.7% with no temperature barrier to 71.4% when temperatures differed by ≥ 2˚C. Greater numbers of fish reject fishways at John Day Dam when water temperatures exceed 18ºC. Temporary temperature barriers contribute to adult passage delay that may result in permanent straying to downstream sites or migration failure.

Dissolved Gas. High spill at dams can create supersaturated dissolved gas condition in tailraces and downstream areas, and there is concern that fish that encounter these conditions may develop gas bubble disease. Results from an archival tag study that monitored fish swimming depths suggest that adults do not avoid plumes of high dissolved gas and frequently experience high dissolved gas conditions. However, most adults remained at depths that provided adequate "hydrostatic compensation" and consequently prevented expression of gas bubble disease. Little is known about the effects of the observed frequent, but short, exposures to supersaturated conditions. Addition of flow deflectors and increased use of surface flow weirs at spillways should moderate dissolved gas conditions in the system. Additional study of this issue may be warranted given the incidence of gas bubble disease symptoms in adults in some years.

River and ocean environment

Flow and Survival. Adult Chinook salmon appear to have lower hydrosystem survival in years with high flow (discharge). This pattern is probably the result of higher fallback and slower migration rates in high-flow years, two energetically demanding aspects of migration. Survival for runs that migrate during typical low-flow times (most fall Chinook salmon and steelhead) has not been correlated with river flow.

Temperature and Survival. Water temperatures in the Columbia and Snake Rivers have been increasing since dam construction began due to development and management of the hydrosystem as well as from regional climate and water use patterns, resulting in longer summers and higher summer temperatures. Adults returning in the late spring, during summer, and in the early fall frequently choose the coolest water available to them to migrate in, but still

frequently encounter stressful temperatures. Higher temperatures were associated with altered migration behavior and lower migration success. Predictions for continued warming will probably adversely affect migrating adults because migration through stressful temperature conditions requires more energy and may contribute to higher rates of prespawn mortality. A study is underway to evaluate effects of temperature exposure on gamete quality and spawning success.

8.3.2 Tributary Hydropower Configurations and Operations

Several hydroelectric dams on Columbia River tributaries pose significant threats to the viability of specific Mid-C steelhead populations, including the Deschutes Westside, Crooked, Umatilla, and Walla Walla populations.

Deschutes River Populations
The Pelton-Round Butte Complex on the Deschutes River at RM 100 significantly impacts abundance, productivity, and spatial structure of the Deschutes Westside steelhead population and to a lesser extent the Deschutes Eastside Population. The complex blocks passage to historical upstream habitats in the Deschutes watershed, including the Crooked River, Metolius River, the Deschutes River upstream to Big Falls, and Whychus Creek. On the Deschutes River, Big Falls (RM 132) is considered to have been the upstream limit of anadromous fish migration (Nehlsen 1995). Summer steelhead were historically present throughout much of the Crooked River subbasin, with the exception of the North Fork Crooked River above Upper and Lower Falls.

Construction of the complex, a system of three dams and reservoirs, began in the late 1950s and was completed in 1964. The complex spans 20 miles on the Deschutes River and also extends into two tributaries, the lower seven miles of the Crooked River and the lower 13 miles of the Metolius River. The complex was constructed with upstream and downstream fish passage facilities, however, by 1966 it appeared that downstream passage through Lake Billy Chinook, the reservoir behind Round Butte Dam, could not be maintained due to poor guidance of out-migrating smolts. The last fish were passed in 1968, and production shifted to state hatchery facilities. In 1974 Round Butte Hatchery was completed at Round Butte Dam, and production shifted to this facility.

With the new federal license issued in June 2005, the joint owners of the project (PGE and CTWSRO) have developed plans to reinitiate fish passage through the complex and reintroduce Chinook and steelhead above the complex. A comprehensive fish passage plan includes development of effective downstream collection and passage for parr and smolt life history stages. The facility is scheduled for completion in 2009.

Potential to Introduce Disease
The reintroduction of steelhead to historical habitats upstream of Round Butte Dam in the Deschutes River subbasin may expose existing resident populations to diseases. Resident trout upstream of the dam have been isolated from the rest of the Columbia Basin for over 30 years. As such, they have not been subject to newly introduced or more virulent disease found downstream. Primary diseases of concern that may affect upstream fish populations include

Infectious Hematopoietic Necrosis Virus (IHNV) and *Myxobolus cerebralis* the parasite that causes whirling disease.

Umatilla River Population

The Boyd Hydro Project has been in operation since the early 1980's and is located at approximately RM 9-10 on the Umatilla River. Water is diverted from the Umatilla River at approximately RM 10 into a mile long canal that routes water to the generating facility where the water is returned to the river. The hydraulic capacity of the facility is 500 cubic feet per second with an average head of 30 feet. Flows for operation of the facility are generally only available during the winter and spring months. The Oregon Water Resources Department and Federal Energy Regulatory Commission have established minimum flows for the Bypass reach of 150 cfs from September through November and 100 cfs from December through August. These flows are well below the instream water right for this reach with priority date of November 3, 1983. The instream water right flows are 300 cfs October through November 15, 250 cfs November 15 – June, 120 cfs in July, 85 cfs August – September 15, and 250 cfs September 15 to October 1.

A low head dam exists at the point of diversion and fish screens are installed across the intake canals. Malfunction of the fish screens led to entrainment of fish and an associated fish kill in 1993. Problems with the screens were corrected and no further problems with the screens have been identified. A fishway exists at the dam structure, but this facility does not meet current fish passage standards for anadromous adult salmonids.

Walla Walla River Population

The Twin Reservoirs Hydro Project, owned and operated by the city of Walla Walla, is located on Mill Creek along a six-mile reach that dips into Oregon (most of this creek is within the state of Washington). The City diverts water from Mill Creek for municipal uses and to generate electricity that is sold on the power market to offset costs of the City's water supply system. Water for both uses is diverted at the same point of diversion and routed to Walla Walla through a pipeline. The current hydraulic capacity of the facility is 38 cfs when the hydro plant is in operation. The City's original 1866 municipal water right has no instream flow requirements. However, when the city operates its hydropower project the following bypass flows are required:

Immediately below project intake:	
Aug-Nov	13 cfs
December	15 cfs
January	20 cfs
February	25 cfs
Mar- Apr	30 cfs
May	25 cfs
June	15 cfs
July	14 cfs

At Kooskooskie	
October	32 cfs
November	35 cfs
December	37 cfs
January	44 cfs
February	53 cfs
March	63 cfs
April	86 cfs
May	64 cfs
June	39 cfs
July	32 cfs
Aug-Sept	31 cfs

The City's hydroelectric license is conditioned to require gauging equipment as necessary to provide full-time, continuous records of project diversions and of streamflow below the project intake. A dam with fishway exists at the point of diversion and fish screens are installed on the intake. The current fish screens were installed in 1999 to replace old screens that were found to result in fish mortality. The screens meet current ODFW and NMFS standards. Recovery team members are unsure of the fishway's compliance with current passage standards.

8.4 Estuarine and Plume Habitat

Changes in estuarine and plume habitat at the mouth of the Columbia River impact Mid-C steelhead juveniles and adults as they undergo the vast physiological changes needed to transition to and from saltwater production. This section summarizes relevant information presented in the Columbia River Estuary Recovery Plan Module (LCREP 2006). The module provides detailed descriptions of limiting factors and proposes recovery actions to improve salmon and steelhead habitat conditions in the estuary.

The Columbia River estuary and plume are considerably degraded compared to only 200 years ago. In terms of absolute size, the estuary tidal prism is about 20% smaller than it was when Lewis and Clark camped along the Columbia's shore (NPCC 2004). This reduction in estuary size is due mostly to dike and filling practices used to convert the floodplain to agricultural, industrial, commercial, and residential uses. Instream flows entering the estuary also have changed dramatically—there has been a 44% decrease in spring freshets or floods, and the annual timing, magnitude, and duration of flows no longer resemble those of the historical hydrograph in the Columbia River (Jay and Kukulka 2002). Changes to the hydrograph are attributed to flow regulation by the hydrosystem, water withdrawal for irrigation and water supplies, and climate fluctuations.

While much remains to be learned about how Mid-C steelhead and other stream-type juveniles use estuarine and plume habitats, scientists generally believe that stream-type salmonids are particularly affected by changes in plume habitat conditions and by predation in the estuary and plume (LCREP 2006). Changes in estuarine habitats affect ocean-type juveniles more because they reside in the estuary longer than stream-type juveniles and tend to use shallow-water

habitats, thus they are more affected by flow alterations that structure habitat and/or restrict access to wetland or floodplain areas than are stream-type juveniles. Mid-C steelhead and other stream-type juveniles have relatively short estuary residence times and use the plume much more extensively than ocean types do. Thus they are more affected by plume habitat conditions. They are also threatened by predation in the estuary and plume (LCREP 2006).

8.4.1 Changes in Plume Habitat

Mid-C steelhead and other stream-type salmonids are affected by the size, shape, behavior, and composition of the plume. The plume is believed to function as habitat, as a transitional saltwater area, and as refugia for juvenile salmonids as they prepare for ocean life (LCREP 2006; Fresh et al. 2005).

Evidence suggests that the plume supports ocean productivity by increasing primary plant production during the spring freshet period, distributing juvenile salmonids in the coastal environment, concentrating food sources such as zooplankton, and providing refugia from predators in the more turbid, low-salinity plume waters (Fresh et al. 2005). Changes in the Columbia River hydrograph alter both the size and structure of the plume during the spring and summer months (NPCC 2000). Changes in the hydrograph also affect plume habitat by reducing fine-sediment inputs leaving the estuary.

8.4.2 Predation

Predation is a primary concern for juvenile and adult Mid-C steelhead during their stay in the Columbia River estuary and plume. Effects of predation are discussed below and in Section 8.7.

Estuary habitat modifications have increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species (Fresh et al. 2005). Stream-type juvenile salmonids, including Mid-C steelhead, are most vulnerable to avian predation by Caspian terns because they use deep-water habitat channels that have relatively low turbidity and are close to island tern habitats.

Native pinnipeds, including harbor seal, Stellar sea lions and California sea lions, also prey on steelhead in the estuary (NPCC 2004). Native pinniped abundance has steadily increased since passage of the Marine Mammal Protection Act in 1972. Diet studies indicate that pinnipeds consume both juvenile and adult salmonids. Mortality of adult salmonids at Bonneville Dam because of sea lions was estimated at 4.1% in 2007 (USACE 2005), however the estimate does not reflect pinniped mortality occurring in the 145 river miles downstream of the dam. There are also no official estimates of downstream mortality on adult spring Chinook and winter steelhead (both of which are stream-type salmonids); however, unsubstantiated estimates are as high as 10%, which would equate to about 29,000 adult fish (LCREP 2006).

The northern pikeminnow and other native piscivorous fish likely pose a lesser concern for Mid-C steelhead in the estuary. The fish prey on ocean-type juveniles more than stream-type juveniles because of their longer estuary residency times and use of shallow-water habitats;

however, it is believed that stream-type juveniles leave faster, deeper water to forage for food in the shallows and also experience mortality from pikeminnow predation.

8.5 Harvest

This section explains the different types of harvest impacts, the types of fisheries and areas that Mid-C steelhead fisheries occur, and the multitude of jurisdictions and processes that influence harvest. The section also provides perspective on historical and current harvest impacts.

Harvest may affect population viability by affecting abundance, productivity, spatial structure and/or diversity. Harvest decreases survival rates relative to an un-harvested population by direct and incidental mortality. Steelhead may be removed at several life stages, ranging from pre-smolts taken in trout fisheries to adults taken after they have returned to natal tributaries to spawn. Harvest, therefore, directly decreases adult abundance (viewed either as the number of spawners or as the number of adult recruits) and productivity, measured as the number of adult recruits per spawner returning to the spawning ground. The extent of this decrease in abundance is usually reported as a harvest rate. Harvest also may be selective and influence diversity and spatial structure viability criteria. Harvest may selectively remove fish based on size, age, distribution or run timing, depending on the gear, timing and location of the fishery. Selectivity impacts have rarely been measured or reported.

The ICTRT identified harvest-related adverse effects as a secondary level limiting factor and the Mid-C Expert Panel did not identify harvest as a primary or secondary threat (Mid-C Expert Panel 2006). Given the current management regulations for mainstem and tributary fisheries we consider harvest to be a threat that does limit viability; however, the combined affect of all fisheries only raises the threat to a secondary level.

8.5.1 Fisheries Management — Historically to Present

Steelhead may be caught in ocean, mainstem Columbia River, or tributary fisheries depending on their distribution, run timing relative to fishery openings and vulnerability to gear. Because of their exposure to fisheries across large geographic regions of the West Coast, Pacific salmon and steelhead management is governed by a number of regional organizations. Fisheries of the Columbia River are established within the guidelines and constraints of the Pacific Salmon Treaty, the Columbia River Fish Management Plan, the Endangered Species Act administered by NOAA Fisheries, The Pacific Fishery Management Council, the states of Oregon and Washington, the Columbia River Compact, and management agreements negotiated between the parties to US v. Oregon.

Fisheries management through these various organizations has resulted in the decline of total exploitation rates for Columbia River salmon and steelhead, especially since the 1970s. Because of these changes, the ICTRT and Expert Panel currently consider harvest a secondary limiting factor for Oregon Mid-C steelhead populations. There has been no direct freshwater non-tribal harvest on wild steelhead from the Mid-Columbia DPS since 1992 when the last wild fish catch-and release regulations on these populations became effective. It is also assumed that steelhead are rarely caught in ocean fisheries. Therefore, all current non-tribal harvest impacts on Mid-

Columbia DPS steelhead are due to incidental by-catch in commercial or recreational fisheries that target hatchery steelhead or other species. Tribal fishers in Zone 6 of the Columbia mainstem (between Bonneville Dam and McNary Dam) continue to retain wild steelhead for commercial sale or for personal use. The impact of these various fisheries is discussed below.

Ocean Fisheries

Columbia River steelhead have been captured in high-seas sampling in the far North Pacific and along the coast of SE Alaska and British Columbia (Burgner et al. 1992). According to Rich (1942), Columbia River steelhead were historically taken along with Chinook and coho in ocean fisheries off the mouth of the Columbia River, but accounted for less than 0.1% of the catch and numbered only in the few hundreds of fish. More recent ocean commercial fisheries have not been monitored for incidental steelhead by-catch, and it is assumed that by-catch is very low. Recreational fisheries in the ocean catch small numbers of steelhead.

Mainstem Commercial Fisheries

Steelhead catch in Columbia River mainstem commercial fisheries was reported starting in 1889, although it is thought that some steelhead were processed along with Chinook (and counted as Chinook) in previous years. The available information is mostly about summer steelhead catch since early reporting focused on the fall fishery, but earlier spring fisheries probably caught some winter steelhead. The maximum annual catch reported was about 492,000 fish (Figure 8-12) (Craig and Hacker 1940). Annual catches were averaging about 189,000 fish by the 1930s. Escapements were not estimated before the late 1930s so the harvest rates due to these early fisheries were not known. All early catch was of wild steelhead.

The Bonneville Dam fish ladder opened in 1938 and allowed escapement estimates to be made on populations that passed above that location. Rich (1942) estimated that the 1938 harvest rate on up-river steelhead was 67%, with 80% of the catch occurring below Bonneville Dam. Subsequent harvest records indicate that commercial harvest rates on up-river steelhead were about 66% between 1938 and 1950 (Figure 8-15) (WDFW and ODFW 2002). Most of the harvest was probably of summer steelhead. Winter steelhead were not identified as a separate race until 1953. From 1939 through 1950, about 8% of the steelhead passing the dam were probably winter steelhead based on run timing.

Total mainstem commercial harvest rates on steelhead (tribal and non-tribal combined) began to decline in the 1950s, and also began to include a mix of hatchery and wild fish. Mainstem harvest rates on up-river summer steelhead declined from about 50% to about 20% from the early 1950s to the early 1970s, while winter steelhead harvest rates declined from about 30% to about 5% over the same period. Non-tribal mainstem commercial fisheries on steelhead were discontinued in 1975. Subsequent impacts in the non-tribal commercial fishery were due to by-catch during fisheries on other species. All steelhead were released in these fisheries, although some release mortality occurred. Tribal commercial harvests in Zone 6 since 1975 ranged from about 30% to less than 10% (Figure 8-13).

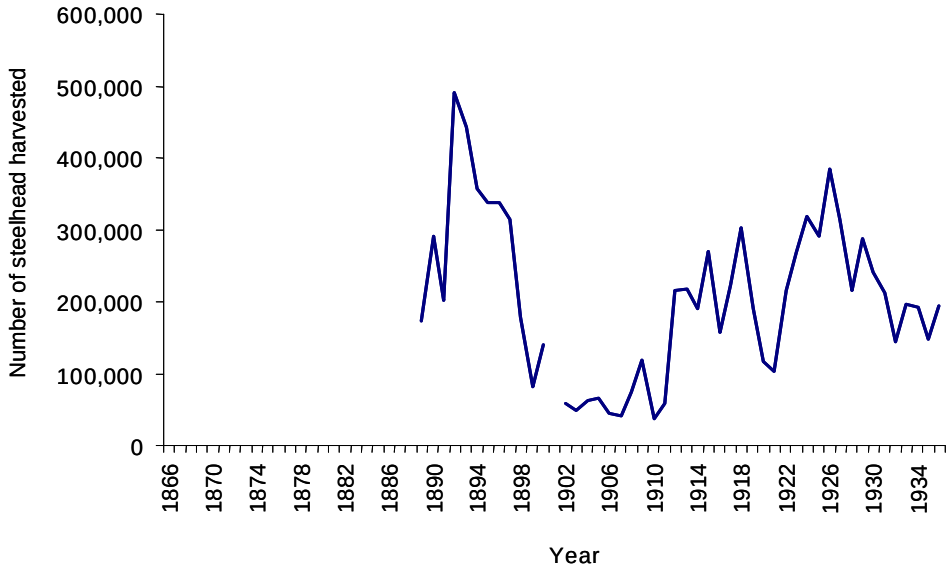


Figure 8-12. Number of steelhead harvested each year in mainstem Columbia River fisheries (1866-1936) (Craig and Hacker 1940).

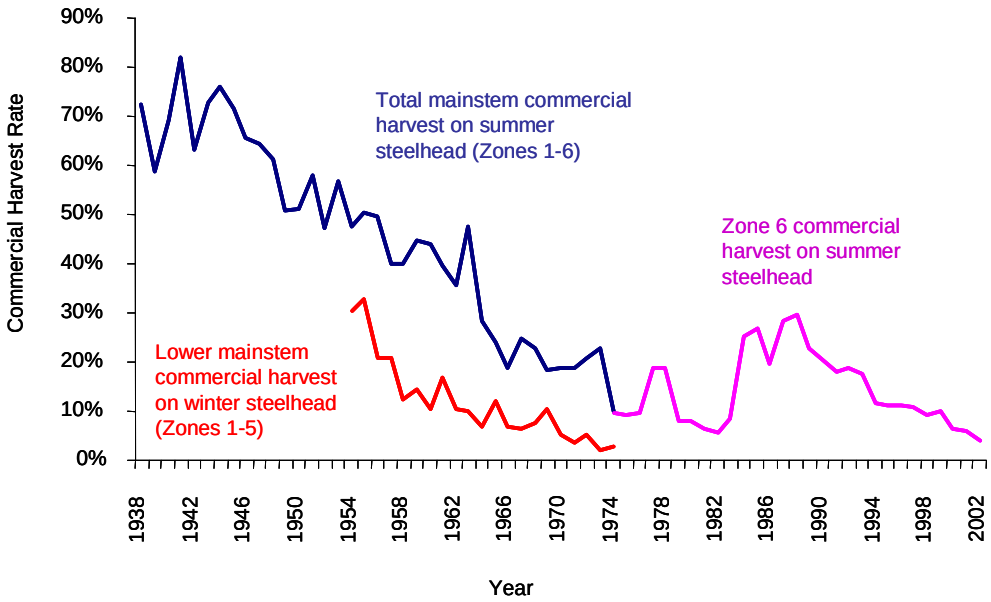


Figure 8-13. Commercial harvest rates on steelhead, 1938 – 2002 (WDFW and ODFW 2002). Non-tribal commercial harvest was discontinued in 1975.

Mainstem Recreational Fisheries

Mainstem recreational fisheries below Bonneville Dam have been monitored by creels since 1964. The harvest rate on summer steelhead ranged from over 16% to less than 1% until 1992

when all fisheries became catch-and-release for wild fish (Figure 8-14). The harvest rate on winter steelhead over the same period ranged from 2% to less than 1%. Current recreational harvest impacts for both life histories are estimated to be less than 1% and are due entirely to hooking mortality.

Recreational fisheries in the mainstem above Bonneville Dam are not monitored, except by punch card estimates. Bubble fisheries at the mouths of some tributaries can be seasonally intense, but the impact rates are unknown except for a bubble fishery at the mouth of the Deschutes. These fisheries have also been catch-and-release since 1992 and impacts to wild fish are thought to be less than 1%.

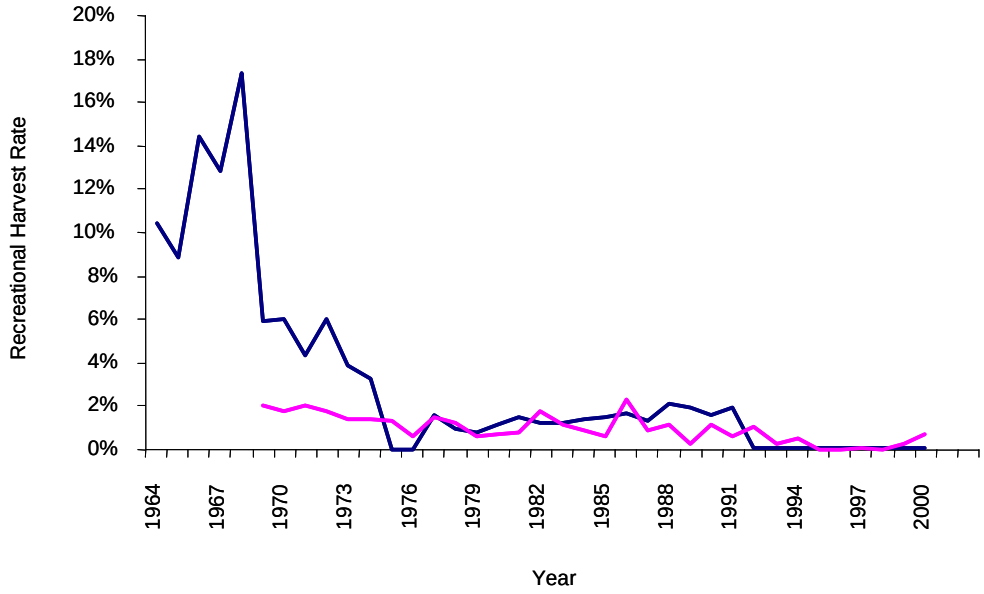


Figure 8-14. Recreational harvest rates on steelhead in the mainstem below Bonneville Dam, 1964 – 2002 (WDFW and ODFW 2002). Blue is summer steelhead while pink is winter steelhead. All mainstem fisheries became catch-and-release in 1992 and the impacts since that year were calculated by the encounter rate and an estimated release mortality.

8.5.2 Allowed Harvest Impacts under NOAA Biological Opinions

Harvest of ESA-listed fish, including the Mid-C steelhead DPS, is controlled by NOAA Fisheries to protect weak stocks. The Oregon Fish and Wildlife Commission also sets limits on certain fisheries to protect the listed stocks. Impacts from harvest regulations to protect Mid-C steelhead are discussed below.

Mid-C Winter Steelhead
The NOAA Biological Opinion for 2008 set a mainstem Columbia River non-tribal impact limit on winter steelhead of 2% (including both sport and commercial impacts), and an average tribal impact of 2.3%. Oregon has FMEPs in place that set tributary impact limits between 0% and 2.5%.

Mid-C Summer Steelhead
The NOAA Biological Opinion for 2008 set a mainstem Columbia River non-tribal impact limit on summer steelhead of 4%, including both sport and commercial impacts. This limit is split across two seasons, with 2% applied to spring and summer fisheries and 2% applied to fall fisheries. An average annual tribal impact of 9.3% (1.9% summer season and 7.4% fall season) is set for Zone 6. Oregon has FMEPs in place or proposed that set tributary impact limits between 0% and 5%.

8.5.3 Actual Recent Harvest Impacts

Monitoring of harvest impacts on Mid-C steelhead is complex because there is no direct non-tribal harvest on wild steelhead from the DPS and all catch is indirect. Indirect effects include incidental mortality of fish that are caught and released, encounter fishing gear but are not landed, or are harvested incidentally to the target species or stock. Monitored and unmonitored fisheries, and impacts due to fishing gear and environmental conditions are discussed below.

Monitored Fisheries
Actual harvest impacts on Mid-C DPS steelhead over the last several years have been incompletely monitored. Monitoring of incidental harvest impacts is complex for two reasons. First, since all caught fish are released, encounter rates and characteristics of encountered fish are difficult for monitors to observe. Second, released fish experience a mortality rate, possibly delayed and difficult to measure, that is highly variable and depends upon what gear is used, how the fish is caught by the gear, how the fish are handled during capture and release, and on environmental conditions.

Ocean commercial and recreational harvest of salmon has generally declined in recent years because of international treaties, fisheries conservation acts, regional conservation goals, the Endangered Species Act, and state and tribal management agreements. Creels on recreational ocean fisheries recorded less than 100 steelhead caught each year in 2003 – 2005. Of these, less than 10 were estimated to be released wild fish mortalities.

The only effort to regularly monitor steelhead by-catch in non-tribal commercial fisheries occurs in the spring Chinook commercial fishery, which impacts primarily winter steelhead, in the mainstem Columbia below Bonneville Dam. This monitoring effort, which began in 2003, employs observers on board fishing boats to measure steelhead encounter rates and uses information from recent literature to set a release mortality rate from gill nets according to mesh size. The estimated impact rate on wild winter steelhead from 2003 to 2005 ranged from 0.5% to 1%. The measurements have an unknown error around these numbers due to the use of point estimates for encounter rates, mortality rates and escapements, all of which actually contain some variance and/or measurement error.

Recreational creel surveys in the lower Columbia mainstem below Bonneville Dam and in the lower Deschutes and Umatilla include questions about wild steelhead releases to estimate encounter rates, and use recent literature to set a hooking mortality rate. Estimated recent impact rates in these recreational fisheries ranged from 0.1% to 1.5% in each fishery. The fish in any particular population may be exposed to several of the fisheries as they move through the

mainstem and into tributaries, but the total recreational impact is probably less than 2.5% in most cases. Again, there is an unknown error around these numbers.

Catch of steelhead in the Zone 6 tribal fishery is easier to monitor since steelhead sold to commercial buyers are counted and measured. However, some tribal steelhead catch, and possibly much of it, may not be reported if they are sold over the bank by individuals or if they are retained for personal use. Tribal biologists make some effort to account for unreported catch, especially in fall fisheries. Reported steelhead catch in Zone 6 winter and spring fisheries for 2003 to 2005 ranged from 0.7% to 7.9% of the winter steelhead run over Bonneville Dam (Table 8-49). Reported steelhead catch in Zone 6 summer and fall fisheries in 2003 and 2004 was 2.6% and 2.7% of the summer steelhead run over Bonneville Dam (Table 8-50). In 2004, the estimated non-reported catch increased the impact to 4.8% of the run at Bonneville. Again, there is an unknown error around these numbers.

Potential impacts due to harvest selectivity are only taken into account in the Zone 6 tribal fishery that is thought to select for larger steelhead because of the use of gill nets with unrestricted mesh sizes. Mesh size in these fisheries is generally selected to optimize the catch of Chinook, the target species. Smaller and younger steelhead are able to escape many nets. The Zone 6 fishery monitors the catch of large steelhead as a separate stock. The 2004 estimated impact on large verses small fish is presented in Table 8-51. Each of the four "stocks" also has a distinct run timing which may account for hatchery/wild differences within size category.

Table 8-49. Estimated impacts (percent of run) on winter steelhead in winter and spring mainstem fisheries (2003–2005).

	Non-tribal Commercial		Tribal	
Year	Number of wild steelhead	Impact rate (of Columbia River mouth escapement)	Total number of steelhead (wild + hatchery)	Impact rate (of Bonneville Dam escapement)
2003	229	1.0%	807	7.9%
2004	238	0.8%	81	0.7%
2005	69	0.5%	208	3.6%

Table 8-50. Estimated impacts (percent of run) on summer steelhead in summer and fall Zone 6 fisheries. Fish numbers include hatchery and wild steelhead, and impact rates are calculated based on the Bonneville Dam escapement.

				Fall							
		Summer		Bonneville Pool		The Dalles Pool		John Day Pool		Total summer/fall	
Year		Fish	Impact rate	Fish	Impact rate	Fish	Impact rate	Fish	Impact rate	Fish	Impact rate
2003	Ticketed	96	<0.1%	4,484	1.3%	2,478	0.7%	2,251	0.6%	9,309	2.6%
2004	Ticketed	714	0.2%	4,611	1.5%	1,792	0.6%	1,219	0.4%	8,336	2.7%
	Est. Total Landed in 2004 (Ticketed, non-ticketed, and C&S)									14,757	4.8%

Table 8-51. Estimated size selectivity of the 2004 Zone 6 fishery. The size breakout is that "Small" fish are less than 78 cm, while "Large" fish are equal to or greater than 78 cm. Estimated impact rates are based on the abundance of each group at Bonneville Dam.

Characteristic	Number of Fish	Estimated Impact Rate
Small hatchery	6,791	3.2%
Small wild	1,963	3.4%
Large hatchery	4,963	17.2%
Large wild	1,040	10.6%

Unmonitored Fisheries

All other fisheries that could encounter steelhead have been unmonitored or irregularly monitored in the past few years. All of these other fisheries must release caught steelhead, but mortality can still occur. The Mid-Columbia steelhead DPS is a diverse DPS that includes winter and summer-run steelhead. Winter steelhead move through the Columbia River between November and May; summer steelhead move through the Columbia River primarily between April and October, although some may be present at other times. Therefore, steelhead from the DPS are present in the mainstem Columbia River nearly year-round, making them potentially vulnerable to a variety of lower mainstem fisheries (Figure 8-15). Some information about potential impacts caused by these fisheries can be inferred by the season and gear, which determine steelhead vulnerability to the fisheries.

The primary fisheries targeting steelhead occur in the Columbia River mainstem and tributaries. These fisheries harvest primarily hatchery fish, and wild fish mortality is incidental. Unmonitored recreational fisheries currently occur in the mainstem Columbia above Bonneville Dam, Fifteenmile Creek (winter steelhead), Deschutes River above Sherars Falls, and in the John Day and Walla Walla rivers.

Unmonitored mainstem non-tribal commercial fisheries target sturgeon, summer and fall Chinook, sockeye, shad and coho. These fisheries all use gill nets of various sizes and occur

between the mouth of the Columbia River and Bonneville Dam, although particular fisheries may target specific zones (Table 8-52). All steelhead taken in commercial nets must be released, but are subjected to encounter rates and release mortalities that vary by gear and season.

Ocean fisheries generally target Chinook and coho salmon, and interception of steelhead is believed to be rare. Currently, however, all ocean commercial fisheries are unmonitored for steelhead by-catch.

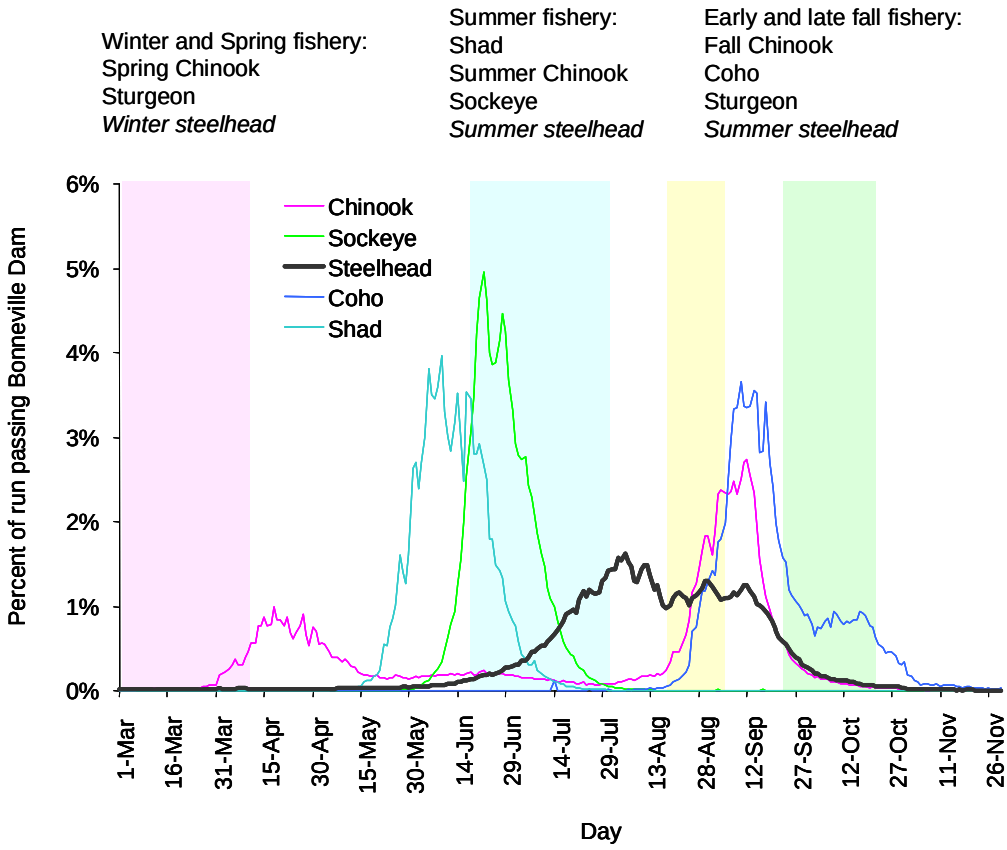


Figure 8-15. Run timing at Bonneville Dam of steelhead and other species that are targeted in mainstem commercial fisheries.

Table 8-52. Characteristics of commercial fisheries in the Columbia River below Bonneville Dam.

Fishery	Non-tribal Season	Non-tribal Gear	Tribal Season	Tribal Gear	Water temperature	Steelhead life history present
Sturgeon	Variable	9 inch min.	Variable		variable	Winter and summer
Spring Chinook	Late Feb. to early April	9 inch min. or 4 ¼ inch max.	February through April	Dip nets, set lines and gill nets with no	low	winter steelhead
Shad	May and June	5 $^{3}/_{8}$ to 6 ¼ inch 10 lb break	no specific fishery	mesh size restrictions	high	Summer steelhead
Sockeye	June and July	4 ¼ inch max.	June and July		high	Summer steelhead
Summer Chinook	June and July	8 inch min.	June and July		high	Summer steelhead
Fall Chinook	August, late Sept.	8 inch min. or 9 inch min.	August through October		high	Summer steelhead
Coho	Late Sept. and October	No min. 5 - 6 inch nets used	September and October		high	Summer steelhead

Encounter Rates and Mesh Size

Encounter rates for Mid-C steelhead increase with smaller mesh nets. Figure 8-16 shows the number of steelhead caught and released per Chinook landed, by mesh size, as observed in the spring Chinook fishery, 2003 to 2005 (test fisheries, research, and observer data combined).

Generally, few steelhead are caught in nets that are 9-inch mesh or larger because most fish are able to swim through them, although steelhead catch has been observed to be as high as one steelhead per four Chinook landed, and the steelhead that are caught are the large fish. Some fisheries use 8-inch minimum mesh size, which has a slightly higher encounter of steelhead, and is also selective for large fish. Mid-size mesh nets (5 to 6 inches) gill or body-wedge steelhead, and have high encounter rates and a high mortality rates. Small mesh "tangle" nets (4¼-inch) tangle most steelhead, causing high encounter rates but lower mortality rates compared to nets that gill fish. Some fisheries that are designed to catch small species (like shad) use nets with low break poundage that allow larger salmonids to break loose from the nets.

Release Mortality Rates, Mesh Size and Environmental Conditions

Release mortality rates in mainstem commercial fisheries vary by mesh size. The highest mortality rates occur when fish are gilled or body-wedged by the nets. In spring fisheries, when the river is relatively cool, release mortalities from nets that gill fish are 40% or higher. Steelhead are gilled or wedged in nets that are 5.5 inches are larger, until the mesh is large enough for the fish to swim through them. Nets that tangle fish, (4¼-inch for steelhead) have mortalities near 20% during the cool spring fisheries. Some fishing practices, particularly long soak times, increase mortality rates. Mortality rates increase dramatically during warm water conditions that occur in the summer and fall.

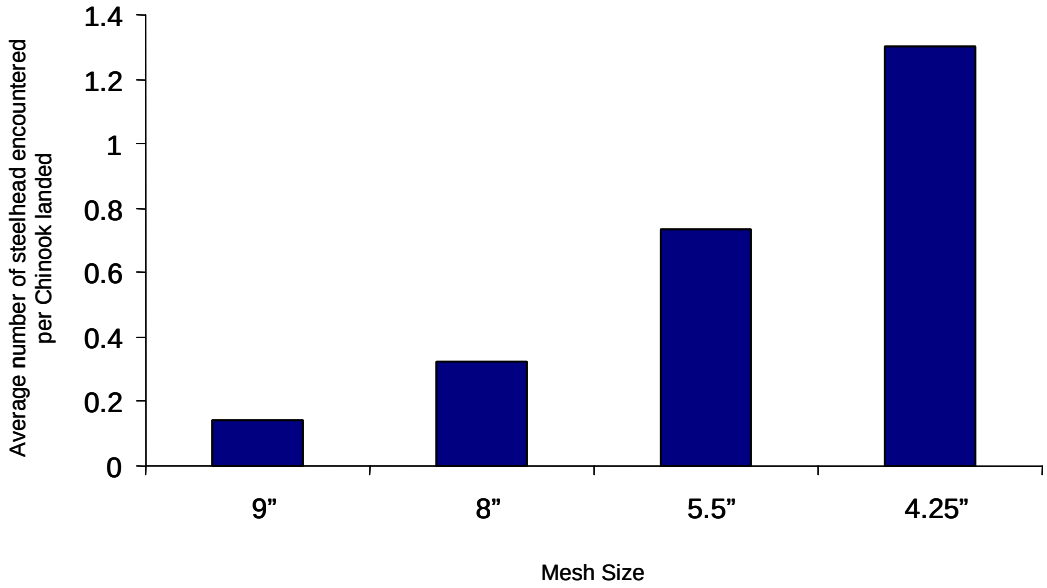


Figure 8-16. Number of steelhead released per number of Chinook landed by mesh size, as observed during monitoring and test fishing in 2003 – 2005 spring Chinook fisheries.

8.5.4 Tributary Fishery Impacts

Fishery Management and Evaluation Plans (FMEPs) have been developed for Oregon Mid-C steelhead populations to address the take of listed fish in recreational fisheries. The primary goal of a FMEP is to devise biologically based fishery management strategies that are consistent with the conservation and recovery of listed populations. FMEPs focus primarily on limiting impacts to abundance and productivity, the two key viability parameters most directly affected by sport fisheries.

Overview

Harvest regulations for Fifteenmile Creek and the Deschutes, John Day, Umatilla rivers and the Oregon portion of the Walla Walla River all reflect strategies that provide protection for natural-origin fish while allowing maximum levels of harvest on hatchery fish. We did not identify tributary harvest as a threat to viability of any of the Mid-C populations. In the review of past and present tributary fisheries, the Mid-C Expert Panel (2006) found that while legacy harvest practices had affected population traits of Mid-C steelhead the impacts of contemporary harvest management on populations in the DPS were much less significant than threats from current land use practices, hatchery programs, and hydropower projects.

Steelhead Sport Harvest Management

In part, ODFW bases steelhead sport fishery harvest rates on the results of model runs that examine the extinction probability risks at different fisheries mortality rates. Chilcote (2001) estimated extinction probabilities for 27 Oregon steelhead populations with respect to a variety of fishery mortality rates. These model runs were then used to assess the impact of fisheries mortality on the status and recovery of steelhead in Oregon (Chilcote 2001). The model looked

at a range of fisheries mortalities from 0% to 75%. The results were stated in terms of the probability of population extinction in 50 years at each mortality rate. For most populations, the modeling suggested that the probability of extinction was essentially zero as long as fisheries mortality rates remained less than 30%. However there was significant variation between populations. The probability of extinction increased dramatically as mortality rates became greater than 40%. Furthermore, once the probability of extinction increased beyond 0.05, the transition to an extinction probability of 1.00 was very rapid. In other words, once mortality rates increase sufficiently to cause the probability of extinction to exceed 0.05, any additional mortality would cause a rapid increase in the likelihood of extinction. Because the transition from low to high risk happens rapidly, there is little room for error (in the model or the measurements of mortality rates). To address this concern, ODFW generally manages steelhead fisheries not to exceed a maximum fisheries mortality rate of to 20%, but it is more conservative when warranted.

Trout Harvest Management

Fisheries managers reduce juvenile steelhead mortality during trout fisheries by requiring catch and release fisheries and by prohibiting the use of natural and synthetic baits. They also restrict fisheries to areas, times and size limits that protect steelhead. Such steps are necessary because steelhead occupy many waters that are also occupied by resident trout species, and it is not possible to visually separate juvenile steelhead from similarly sized stream-resident rainbow trout.

Juvenile steelhead and resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences; so, assumably, catch-and-release mortality studies on stream-resident trout would also apply to juvenile steelhead. Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and flies (Mongillo 1984; Taylor and White 1992; Schisler and Bergersen 1996; Schill and Scarpella 1997; Wydoski 1997). As a result, the prohibition of natural and artificial bait is believed to reduce juvenile steelhead mortality more than any other angling regulatory change. Hook-and-release mortality of juvenile steelhead is expected to be less than 10% and approaches 0% when anglers are restricted to use of artificial flies and lures with barbless hooks.

Studies show that catch and release mortalities tend to increase for juvenile steelhead as water temperatures increase, with over 80% of the observed mortalities in one study occurring above 21° C (Taylor and Barnhart 1997). Consequently, fisheries are restricted in some areas during times of the year when stream temperatures are high.

Fifteenmile Creek

Under current fisheries regulations, adult steelhead cannot be legally retained in any of the minor Columbia River tributaries (Fifteenmile, Mill or Chenoweth creeks). Steelhead are rare in Mosier, Rock and Threemile creeks; though they have been observed in each of the streams. Conservative trout angling regulations are currently in effect on Rock, Mosier, Chenoweth, Mill, Threemile and Fifteenmile creeks and provide a high level of protection for steelhead juveniles.

Chenoweth, Mill, Rock, Mosier, Threemile and Fifteenmile creeks open to trout angling the fourth Saturday in May and remain open through October. It is believed that most steelhead

smolts emigrate for their natal streams before the opening date. Further, Chenoweth, Mill, and Fifteenmile Creeks are restricted to catch and release angling with artificial lures only.

Rock, Mosier and Threemile creeks have very limited areas that are accessible to steelhead. Rock Creek has a porous alluvial fan at its mouth and fish passage across this fan is possible only at high winter and spring flows, and natural barriers that are not passable to steelhead are present a short distance upstream. Anadromous fish are blocked from accessing all but the lower 400 meters of Mosier Creek by an impassable falls. Steelhead access in Threemile Creek is severely restricted by improperly functioning culverts under Interstate 84, and culverts under Highway 197 block access approximately 300 meters above that point. Trout fishing in these streams does not open until the fourth Saturday in May, but is not restricted to catch and release or artificial lures. Five trout can be harvested per day with an 8-inch minimum length limit. Managers are not aware of any trout angling effort in the portions of these streams that are accessible to steelhead.

In Fifteenmile Creek, juvenile steelhead receive significant protection from angling mortality. As noted above, anglers are restricted to artificial flies and lures for all angling. The incidental mortality associated with these fisheries is due to impacts from the catch and release of juvenile steelhead. ODFW has estimated that the mortality rate from the trout fisheries is less than 1% of the juvenile steelhead in Fifteenmile Creek, based on the low effort observed, and the low catch and release mortality. ODFW (2005) has submitted to NMFS a FMEP for fisheries affecting Mid-C steelhead in Fifteenmile Creek and the other mainstem Columbia River tributaries downstream of the Deschutes River (as part of the Deschutes River Basin FMEP), for review and concurrence under Limit 5 of the 4(d) rule for Mid-C steelhead (71 FR 834).

Deschutes River

The Deschutes River FMEP (ODFW 2005c) submitted to NMFS, specifies that the management objective is to provide consumptive recreational fisheries on adult hatchery summer steelhead, non-listed salmon, and resident redband trout in the Deschutes River while allowing for the recovery of ESA listed steelhead. Only adipose fin-clipped adult steelhead may be retained in the fisheries. The source of mortality in these selective fisheries is from the hook-and-release of listed fish.

Steelhead Sport Harvest Management

Specific exploitation rate goals for hatchery summer steelhead in the Deschutes River have not been identified, but fisheries managers recognize that maximizing removal of hatchery origin summer steelhead through angling is important to maintain the genetic health of the wild population. Removing hatchery steelhead utilizing harvest reduces the number of hatchery fish available to spawn in the wild. Continuing sport angler removal of hatchery steelhead from the Deschutes River is an important tool to meet management objectives.

The importance of sport angler removal of hatchery steelhead in the Deschutes River is underscored by extinction probabilities estimated by Chilcote (2001). The current long-term average percentage of hatchery steelhead in the Westside population is estimated to be 18% and 34.4 % for the Eastside population. Chilcote (2001) concluded that hatchery-origin fish spawning naturally in the Deschutes River subbasin posed significant risk to persistence of

natural populations. Reduction in the proportion of natural spawners that are hatchery origin would significantly reduce the risk of extinction. It is crucial that subbasin fish managers continue to use sport anglers as a tool to maintain and even increase removal of hatchery fish from the spawning population.

The best available information suggests that the fishing mortality rate for summer steelhead in the Deschutes River is expected to be 1% (section 1.4.1 of the FMEP; ODFW 2005c). This estimate was derived using a 10% encounter rate and a 10% catch-and-release mortality rate (Hooton 1987). Also, as discussed earlier, catch and release mortalities tend to increase as water temperatures increase, with over 80% of the observed mortalities in one study occurring above 21° C (Taylor and Barnhart 1997); and water temperatures in the Deschutes can approach 21° C during parts of the summer. As a result, a 10% hooking mortality was used to estimate fishing impacts on natural summer steelhead. The average recreational catch rate of Round Butte Hatchery origin steelhead from the mouth to RM 43 has been estimated to be 9.3% for the last 5 years. Assuming that natural steelhead are also caught at this rate and that they suffer a 10% hook-and-release mortality, fishery impacts of less than 1% are expected for natural-origin steelhead.

The steelhead fishery will continue as proposed as long as the average natural spawning summer steelhead escapement is above 1,479 at Sherars Falls. The trend in natural steelhead escapement will be monitored annually. If there is a downward trend or if escapement is expected to fall below 1,479 in the foreseeable future, fishery restrictions will be imposed.

The current harvest rate on steelhead is believed to be well below that seen in the past. Cramer et al. (1997) reviewed harvest rates of adult steelhead in sport fisheries in Oregon and Washington before wild (unmarked) steelhead release regulations and concluded that harvest rates on natural summer steelhead were in the neighborhood of 50%. While past harvest impacts to adult steelhead in the Deschutes River before the start of mandatory unmarked fish release regulations in 1979 are unknown, harvest rates in the Deschutes River could have been of this magnitude during some years. It is estimated that the annual harvest impacts for fisheries covered in this FMEP will remain at less than 1.5%, which is well below the 50% observed in the past.

ODFW sport harvest regulations for the Deschutes are also designed to protect holding and spawning steelhead. ODFW believes that the vast majority of mainstem steelhead spawning occurs in that portion of the Deschutes River bordering the Warm Springs Reservation (RM 71 to 100). This river reach is closed to all angling from January 1 to the fourth Saturday in April each year. This closure minimizes disturbance to holding and spawning steelhead and outmigrating smolts.

Steelhead Tribal Harvest

The Warm Springs Tribal steelhead fisheries typically occur from September through December. The majority of fish are harvested at Sherars Falls and creel surveys are conducted to estimate harvest. Typically steelhead are not the target species but are caught incidentally during the Fall Chinook salmon fishery. Tribal members fish from scaffolds and with hook and line. Scaffold fishing is the more common method. Targeted hook and line steelhead fisheries occur on the Reservation lands but are minimal in scope and impact. In response to the listing of Mid-C

steelhead, the Warm Springs Tribal Council has annually approved Tribal Resolutions requiring the release of wild steelhead. Compliance with the resolution is generally good; however a few wild fish are retained. Table 8-53 shows harvest of wild and hatchery fish from 1980-2005. Prior to 1999 natural-origin fish were retained; after 1999 the majority of the natural-origin fish were released back into the Deschutes River. Since 1992, the estimated harvest of natural-origin fish has been well below previous years and has generally been low.

Table 8-53. Deschutes River expanded summer steelhead tribal harvest estimates for Sherars Falls, by run year (June 16 – October 31). Harvest estimates are for the dip net and hook and line fisheries combined (ODFW/CTWSRO Creel Data).

Year	Anglers/ Fishers	Hours	Tribal*	
			Wild	Hatchery
1980	944	7,357	981	1,309
1981	605	5,025	688	772
1982	516	4,628	549	1,066
1983	954	5,131	903	3,286
1984	576	5,553	1,600	2,730
1985	710	6,126	1,463	2,728
1986	523	5,848	1,225	3,729
1987	724	4,736	972	1,800
1988	744	5,978	339	939
1989	973	6,347	529	1,294
1990	602	4,232	301	1,300
1991	175	930	75	565
1992	36	332	10	65
1993	64	246	15	79
1994	82	400	12	130
1995	114	417	1	85
1996	80	355	1	155
1997	238	1,001	27	428
1998	304	1,123	135	760
1999*	275	1,451	0	419
2000	303	1,225	42	616
2001	261	1,106	65	700
2002	345	1,984	17	585
2003	411	1,809	22	287
2004	478	1,919	69	546
2005	671	3,031	23	505

Every year, the Tribal Council sanctions a sport fishery that occurs in select areas on and bordering the Warm Springs Reservation. These fisheries are for non-tribal anglers and require the purchase and possession of a permit. The regulations that are adopted by the Tribal Council are very similar to the ODFW regulations, where the fishing areas overlap. In 1999 the fishing area in the Warm Springs River near the Kah-Nee-Tah Resort was closed to reduce the impact of hook and line angling on steelhead. Also, the area along the Deschutes River from Dry Creek to Trout Creek is closed from November 1st until the third Saturday in April. Camping, fishing, or landing on all islands west of the middle of the main channel (Reservation Islands) is prohibited, and critical spawning areas for steelhead and fall Chinook are posted and the regulations require that no fishing is to occur within 100 feet of the signs. These regulations greatly reduce the amount of fishing pressure and harassment on the west bank of Deschutes River along the Reservation boundary during the steelhead run. Given the low exploitation and restrictive current regulations, no additional Tribal management regulations are proposed.

Salmon Harvest Management

Spring Chinook are reared at the Round Butte Hatchery and at the Warm Springs National Fish Hatchery. Spring Chinook are harvested principally from April 15 through June 15, and virtually all sport and tribal spring Chinook harvest takes place in the one-mile reach immediately downstream from Sherars Falls. This reach is characterized by very deep, high velocity areas where the river is constrained between bedrock cliffs; conditions that restrict use by significant numbers of juvenile steelhead. In addition, while natural bait is legal in the three-mile stretch of river downstream from Sherars Falls, anglers tend to use large hooks and bait when angling for Chinook salmon. Very few adult steelhead are caught in this fishery because very few steelhead are in this area at this time of year. The mortality on steelhead (adults and juveniles) caught and released in the fishery is estimated to be very low.

Fall Chinook salmon return to the Deschutes River starting in late June and early July. The sport harvest scenario for fall Chinook is very similar to that for spring Chinook, with the majority of the sport harvest taking place in the one-mile stretch immediately downstream of Sherars Falls. Greater numbers of natural summer steelhead are caught and released during this fishery, given the greater number of natural steelhead present at the time of this fishery. The increased hooking mortality to natural summer steelhead due to the use of bait is unknown, but is likely small given the spatial and temporal constraints on the fishery.

For all of the tributary fisheries described in the FMEP, the impacts are estimated to be less than 1.5% of the natural-origin summer steelhead.

Trout Harvest Management

Trout fisheries for native redband trout are ongoing in the Deschutes River. Trout angling is closed from the northern boundary of Warm Springs Reservation upstream to Pelton Regulating Dam from November 1 through the fourth Saturday in April. This closure minimizes disturbance to rearing juvenile steelhead before spring migration. Redband trout are very abundant in the lower Deschutes River, where estimated population densities of more than 2,000 trout (greater than or equal to eight inches) per mile have been observed. The total abundance of redband trout in the lower 100 miles of the Deschutes River likely exceeds 100,000 individuals,

and the magnitude of that population provides an effective buffer against juvenile steelhead mortality in the redband trout fishery.

Juvenile steelhead are protected through the current fisheries regulations. There is a two fish bag limit for redband trout, and only fish between 10 and 13 inches in length can be retained. Other trout must be released unharmed. Most natural steelhead smolts are less than eight inches in length. Effort and harvest information collected from redband trout anglers in the lower Deschutes River for many years shows that the current trout slot length limit and bait ban combine to nearly eliminate consumptive trout angling. Data from harvest samples in the lower 43 miles of the Deschutes consistently show that anglers harvest approximately 3% of their total redband trout catch. This harvest rate translates into an actual harvest of less than 1% of the redband trout population in the river each year. This very low harvest rate also protects juvenile steelhead caught incidentally by redband trout anglers. Further protection was provided in 1978 with the end of stocking of legal-sized rainbow trout, which limited impacts to natural juvenile steelhead that are harvested incidentally to the catchable trout fishery. Protection is also provided by restricting anglers to artificial flies and lures for all angling on 97 of the 100 miles open to fishing in the lower Deschutes River.

John Day River

Fishery impacts on adult and juvenile steelhead in the John Day River have been minimized under the fishing regulations established in the FMEP, with impacts from all tributary fisheries estimated to be less than 2% of the natural-origin fish. The John Day River FMEP (ODFW 2005a) submitted to NMFS, specifies that the management objective for the plan is to conduct consumptive fisheries for marked adult hatchery steelhead, resident rainbow trout, and warmwater species. Fisheries for spring Chinook salmon have not been open in the John Day River subbasin since 1976.

While specific exploitation rate goals for hatchery summer steelhead in the John Day River have not been identified, managers stress that maximizing removal of hatchery origin summer steelhead through angling is important to maintain the genetic health of natural populations. Removing hatchery steelhead utilizing harvest reduces the number of hatchery fish available to spawn in nature. Continuing sport angler removal of hatchery steelhead from the John Day River is an important tool to meet management objectives. To help increase harvest of hatchery steelhead from the John Day River, managers have adopted a 3 fish per day, no annual limit regulation for adipose fin-clipped steelhead.

Steelhead Sport Harvest Management

Adult steelhead fishery impacts are minimized by season and areas closures. Listed below are the areas and times that are open to adult steelhead fisheries.

- Mouth of the John Day to Cottonwood Bridge RM 38: Year round.
- RM 38 Cottonwood Bridge to RM 185 at Kimberly: Year round.
- RM 185 at Kimberly to RM 257, the mouth of Indian Creek: Sept.1 to April 15.
- Mouth of the North Fork to RM 60 at Hwy 395 Bridge: Sept.1 to April 15.
- Mouth of the Middle Fork to RM 24.2 at Hwy 395 Bridge: Sept.1 to April 15.
- South Fork: Closed to adult steelhead angling.

- All other tributaries and portions of the Middle Fork, North Fork and Mainstem not listed: Closed to adult steelhead angling.

In addition, ODFW has implemented restrictive regulations permitting only the retention of marked adult hatchery steelhead and requiring the release of natural-origin adult steelhead in the John Day subbasin. Punchcard estimates during years when retention of wild steelhead was permitted indicate that wild fish harvest rates in the John Day River subbasin averaged approximately 12% of the annual return (ODFW 2005a). This estimate includes years when bag limits allowed retention of 2 fish per day and up to 20 fish per year, and also includes a significant component of hatchery fish in some years. For 1996 (the only year in which statistical creel data are available), the proportion of hatchery fish in the harvest below Cottonwood Bridge (where most fish are caught) was approximately 48% (ODFW 2005a); so the estimated 12% harvest rate on natural-origin fish is likely higher than actual. Based on these data, ODFW estimates the potential encounter rate of natural-origin steelhead in the John Day River fishery to be in the range of 6 to 12% of wild steelhead present in the subbasin. A fishery requiring release of wild fish has been in effect since 1995, so in-subbasin fishery related mortality rates (likely less than 1% [12% encounter rate x 5% hooking mortality rate = 0.6%]) and angler effort have dropped substantially since the hatchery only harvest regulation was implemented.

The 5% catch and release mortality rate is conservative for steelhead based on the mortality estimate for steelhead of 3.4% developed by Hooton (1987). Studies show that catch and release mortalities tend to increase as water temperatures increase, with more than 80% of the observed mortalities in one study occurring above 21° C (Taylor and Barnhart 1997). While the adult steelhead fisheries in the John Day River do not begin until September when the water temperatures are slightly elevated, steelhead returns and fishing effort do not increase until mid-October when flows increase and water temperatures drop below 21° C.

ODFW estimates that the annual harvest impacts on natural-origin fish under the FMEP will remain at less than 1.5% annually. Harvest impacts on adult steelhead in the John Day River before the start of mandatory unmarked fish release regulations in 1996 are unknown, but were clearly greater than the current level

Trout Harvest Management

While the John Day River is not highly regarded by most anglers for its trout angling opportunities, redband trout occur throughout the subbasin and westslope cutthroat trout occur in the upper John Day River system and a few North Fork tributaries. Presently, angling effort for trout is targeted to standing water bodies where ODFW routinely stocks hatchery fingerling or legal sized rainbow trout. Past harvest impacts on juvenile steelhead during trout fisheries in the John Day River are unknown.

Historically, most trout angling effort in streams was associated with areas where legal or fingerling rainbow were released. An evaluation of ODFW's fingerling rainbow stocking program in the South and Middle forks was completed in 1995. The evaluation concluded that the stocked fingerling were not being caught by the few anglers interviewed, and that there were

adequate numbers of wild, legal-sized rainbow trout in both streams to support the modest fishery.

Since 1998, there have been no releases of hatchery rainbow trout into any streams within the subbasin. The trout-angling season for streams does not open until the fourth Saturday in May and the minimum legal size is 8 inches. Monitoring of smolt migration at irrigation diversion bypass traps and out-migrant traps (screw traps located on the South Fork John Day River, Middle Fork John Day River and mainstem John Day River) indicates that most steelhead smolts emigrate before the second week in May. Juvenile *O. mykiss* length frequency data from selected steelhead spawning and rearing streams indicate that 98% of them are less than six inches long. The combination of a late opener and the eight-inch minimum size limit provides significant protection for juvenile steelhead and smolts. In addition, the following streams are closed to all angling: the Granite Creek system (North Fork John Day tributary), and the Middle Fork John Day River from Highway 7 to Summit Creek.

It is difficult to quantify the impacts to juvenile steelhead from sportfishing because of the lack of information specific to the John Day River. However, given the current regulations that are in place to protect juvenile steelhead, the dispersed nature of the fishery and cessation of trout stocking after 1997, it is estimated that <1% of rearing juvenile steelhead in the John Day River subbasin are caught and released in the trout fishery.

Warmwater Fisheries Harvest Management

Warmwater fisheries in the subbasin are believed to have little, if any impact on the steelhead population because they occur primarily at a time and location where juvenile and adult steelhead are not present. These fisheries are open only during trout, salmon, or steelhead seasons, and the angling is largely dependent upon water temperatures and water clarity. Significant angler effort does not begin until mid- to late-May in most years. The bulk of the warmwater fishery takes place in the lower mainstem from RM 40 to RM 185 where steelhead do not rear. There is virtually no warmwater fishery in the John Day River above Kimberly or above Wall Creek on the North Fork John Day River because the abundance of smallmouth bass is relatively low. The probability of encountering juvenile steelhead increases as one progresses upstream due to improved rearing conditions. Additionally, most warmwater anglers use terminal angling gear that reduces the probability of catching steelhead, and if hooked, it facilitates easy release.

Umatilla River

The Umatilla River system supports steelhead sport and tribal harvests. Steelhead are also captured in fisheries targeting resident trout, warmwater fish and Chinook salmon.

Steelhead Sport Harvest Management

The Umatilla River steelhead sport fishery is directed at the harvest of hatchery steelhead produced by the Umatilla Hatchery and stray hatchery fish. Current angling regulations require the release of natural-origin (unmarked) steelhead in the Umatilla River. The general steelhead season for the Umatilla River (September 1 – April 15) and open area (mouth to west reservation boundary) seek to maximize harvest opportunity of hatchery steelhead while minimizing impacts to wild fish. The open season encompasses the period of adult migration into and through the

Umatilla River. The open area includes approximately 56 miles of the mainstem Umatilla River and does not include spawning areas of natural-origin summer steelhead. The bag limit of 3 hatchery steelhead per day with no annual limits seeks to balance maximization of harvest and equally distribute the harvest among the angling constituents. When necessary, the Oregon Commission can adopt and implement emergency regulations that further restrict fisheries for conservation purposes.

The abundance threshold for triggering harvest management regulation changes is the 6-year average natural-origin adult steelhead escapement of at least 650 unmarked steelhead; approximately two times the critical fishery conservation threshold recommended by Chilcote (2001).

The draft FMEP for the Umatilla (ODFW 2005b) focuses primarily on the potential impacts of harvest on abundance and productivity, the two key viability parameters most directly affected by harvest. Although fisheries with high harvest rates and fisheries that are selective on phenotypic traits can influence spatial structure and diversity, the tributary fisheries in the Umatilla River are not selective and have little or no influence on spatial structure and diversity.

Chilcote (2001) estimated extinction probabilities with respect to a variety of fishery mortality rates and demonstrated that for the Umatilla population there is substantial increase in risk of extinction for harvest greater than 10% (Table 8-54). Within the Umatilla, it is estimated that fisheries will result in a mortality rate of approximately 1.5% on the natural-origin fish. This estimate is based on an assumed post-catch and release mortality rate of 5% and a maximum fishery interception rate of 30% for the natural-origin fish. The interception rate for wild fish in the most recent years has been less than 25% and averaged 17%. The net mortality impact on natural-origin fish is between 1-2%. This is considerably less than the within subbasin maximum mortality objective of 5% (ODFW 2005b) natural-origin fish.

Table 8-54. Results of Population Viability Analysis (PVA) simulations of estimated probability of extinction in 50 years for Umatilla steelhead under 16 different adult mortality rates.

	Percent Adult Mortality Rate															
Population	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**	**75**
Umatilla	.01	.08	.21	.57	.85	.98	1.0	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

CTUIR Tribal Steelhead Harvest

Tribal fisheries are conducted within the Umatilla subbasin and both natural- and hatchery-origin fish are allowed to be harvested. CTUIR estimated that 50-100 fish are harvested annually, of which about 33% are natural-origin fish (Gary James, personal communication, 2006). Tribal harvest is not considered a significant threat.

Trout Harvest Management

Significant protection for juvenile steelhead is provided under current trout fisheries regulations. Redband trout fisheries in the Umatilla subbasin have been adapted to protect wild *O. mykiss* in natural production areas. The upper Umatilla and tributaries upstream from the eastern boundary of the Umatilla Indian Reservation have been catch and release only, and flies and lures only for

redband trout since 1995. Streams within the boundaries of the Umatilla Indian Reservation are under jurisdiction of the CTUIR. Other steelhead production streams, including Meacham Creek and Birch Creek, have a bag limit of five trout per day with an eight-inch minimum length. Both of these streams have limited public access. The lower 20+ miles of Meacham Creek are only accessible via the Union Pacific Railroad right-of-way that is managed to exclude public entry. Upper parts of the Meacham drainage are lands under private ownership. The lands adjacent to Birch Creek are all private with limited public access available. Mortality due to harvest on these streams, while not quantified, is estimated to be low.

The redband trout fishery is open from the fourth Saturday in May to October 31, with an eight-inch minimum length to minimize angling impacts on adult steelhead spawners and outmigrating smolts. Thus, the fishery through the summer and fall likely focuses on resident trout (eight-inch minimum length) rather than younger fish, which could be either resident or anadromous juveniles.

All stocking of hatchery rainbow trout was ceased in 1999 in streams within the Umatilla subbasin to protect wild stocks of *O. mykiss*. Legal-sized rainbow trout have been historically stocked in many streams throughout the Umatilla subbasin. However, stocking over the past decade has only occurred in the Umatilla River (downstream of steelhead production areas) and lower McKay Creek. From 1990 through 1993, approximately 8,000 legal sized Cape Cod stock rainbow trout were stocked in the forks area of the upper Umatilla River. In 1994, stocking of legal sized rainbow trout was moved downstream to the Pendleton area to reduce interaction with wild O. *mykiss* in the upper Umatilla River.

Fishing effort is currently much lower than in previous years because of the elimination of hatchery catchable trout stocking in the Umatilla River and the conservative, selective fishing regulations currently in place. It is difficult to quantify the impacts to juvenile steelhead from sportfishing because of the lack of information specific to the Umatilla River. However, given the current regulations that are in place for juvenile steelhead, the dispersed nature of the fishery and cessation of trout stocking, it is estimated that <1% of rearing juvenile steelhead in the Umatilla River subbasin are caught and released in the trout fishery.

Warmwater Fishery Harvest Management

The warmwater game fish fishery is focused in the lower Umatilla River downstream from Echo; isolating the fishery from areas where anglers would likely encounter significant numbers of steelhead parr. Smolts and adults are the only life history forms that would be expected in the lower Umatilla River. Adult wild steelhead are required to be released unharmed. The warmwater gamefish fishery is closed from April 16 through the third Saturday in May, the peak of the steelhead smolt out-migration. During creel census of the fall and spring salmon fisheries and the steelhead fishery, personnel also census warmwater anglers to gather baseline data on this fishery. Data from 1998 through 2000 show that warmwater anglers catch very few smolts. The potential impact is not of concern.

Spring Chinook Harvest Management

Mortality on steelhead (adults and smolts) caught and released by spring Chinook salmon anglers is low and does not warrant further restrictions. The Umatilla River spring Chinook fishery

occurs in two sections of the Umatilla River: section 1 from Hwy 730 Bridge upstream to Threemile Dam during April 16 – May 21 and section 2 from Threemile Dam upstream to the western boundary of the Umatilla Indian Reservation (RM 55) from April 16 through June 30. The fishery begins after most steelhead adults have migrated above the fishery area to spawning areas. Although this fishery occurs through the peak of the steelhead smolt out-migration, the fishing tackle is not conducive to catching of smolts (large hook sizes and large lures).

Walla Walla River

Steelhead in the Walla Walla River system are captured in the tributary steelhead fishery and in resident trout fisheries.

Steelhead Harvest Management

The Walla Walla River steelhead fishery is directed at catch and release of natural-origin fish and harvest of stray hatchery steelhead. The season occurs from December 1 through April 15 and the area open to angling is from the Oregon-Washington state line upstream to the confluence of the North and South forks. The entire upper subbasin has been set aside as an adult steelhead sanctuary area and will remain closed to steelhead angling. The daily bag limit (three fish/day) is restricted to adipose fin-clipped steelhead only. Natural-origin steelhead are required to be released unharmed. Harvest of natural-origin steelhead or further restrictions on this fishery are not anticipated in the foreseeable future.

This fishery is managed based on the six-year rolling average of returns to Nursery Bridge Dam. As long as the rolling average natural-origin spawner escapement is above the critical fishery conservation threshold of 220 adults, the current fishery regime will be maintained (draft FMEP, revised September 2005). However, the abundance of natural-origin steelhead is monitored and evaluated annually. If there is a downward trend of wild adult steelhead below the objective of 220, the fishery will be modified to reduce impacts. Possible adjustments could be gear restrictions, restriction of the open area and/or season length.

There is also a process to make in-year adjustments to fisheries when returns approach the critical fishery conservation threshold. To make reasonable predictions for steelhead returns to the Walla Walla River, ODFW has developed a regression of Bonneville wild Group A summer steelhead counts and wild steelhead counts at Nursery Bridge Dam (Figure 8-17). This regression is used to develop a steelhead return estimate for the Walla Walla Annual Operation Plan to provide managers with a forecast model. As discussed above, the fishery will be managed based on a rolling six-year average. However, the Bonneville predictive tool will also be used to adjust fishery management within-year if escapements are expected to approach and/or go below the critical fishery conservation threshold.

As seen in Figure 8-17, the data show two time series trends that are quite distinct; the years 1993 through 1995 plot higher and result in a steeper trend line than do data from 1996 to 2000. While the apparent shift in population productivity in relation to the total wild Group A summer steelhead run is not fully understood, it is distinct enough for use in developing run predictions. The data and trend line from 1996 to 2000 are used to develop in-year run forecasts based on wild Group A returns to Bonneville. This conservative run estimate seems a prudent approach since this is the most current trend.

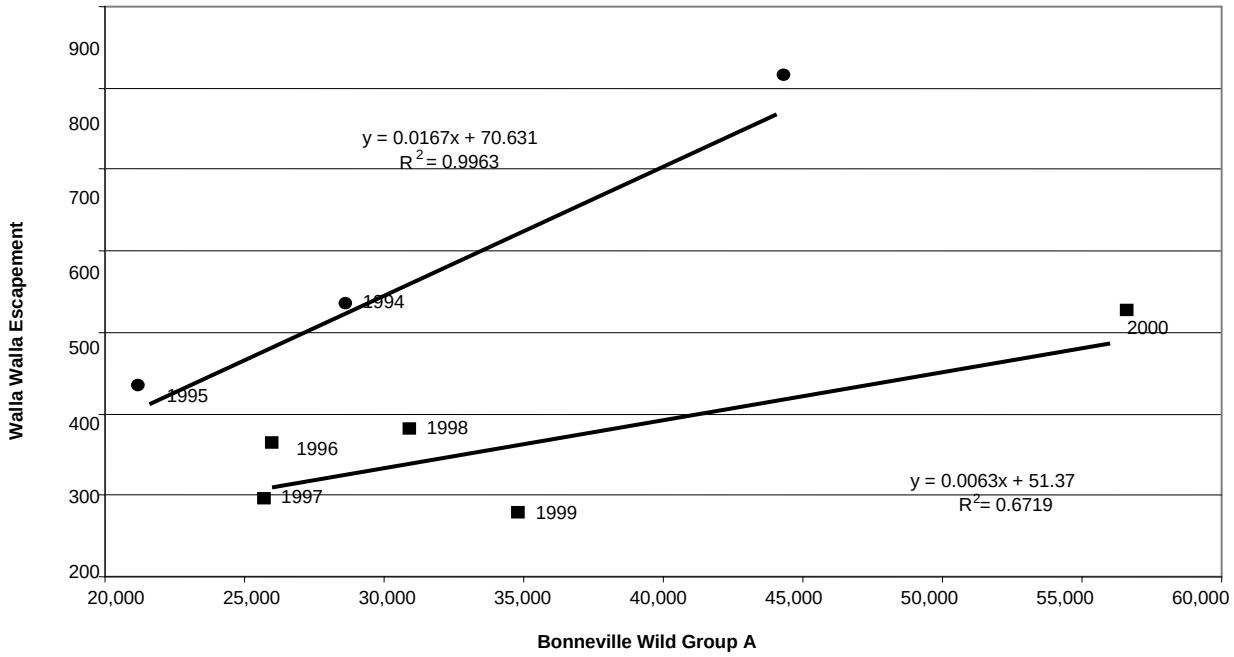


Figure 8-17. Relationship of Bonneville Dam wild Group A steelhead counts to estimated escapement above Nursery Bridge Dam, Oregon for run years 1993-1994 through 1996-2000.

Based upon Population Viability Analysis simulations of estimated extinction probability for 27 steelhead populations in Oregon, Chilcote (2001) recommended a maximum fishery mortality rate for most wild steelhead populations of 20%. The fisheries that currently occur do not exceed this exploitation rate.

Within the Walla Walla, it is estimated the current and proposed future fisheries will result in a mortality rate of approximately 1.5% on the natural-origin fish. This estimate is based on an assumed post-catch and release mortality rate of 5% (from Hooton 1987) and a maximum fishery interception rate for natural-origin fish of 30%.

Creel surveys conducted by the WDFW from 1997 to 2000 indicate that approximately 27% of the steelhead caught during the Washington Walla Walla subbasin recreational steelhead fisheries are natural origin. Because there are currently no estimates of total wild steelhead escapement to the entire Walla Walla subbasin, these creel data cannot be used to determine the catch rate of natural-origin fish in the Walla Walla population. However it does indicate that significant numbers of wild fish are caught. The WDFW (2001) estimates that an average of 438 natural-origin adults are caught and released in their steelhead fishery, resulting in an estimated mortality of 22 natural-origin adults. Natural-origin adults from both the Touchet and Walla Walla populations are caught and released in the fishery. This level of mortality results in 1-2% annual impact given the recent 10-year geomean abundance of 1,000 adults in the Walla Walla population.

Trout Harvest Management

To minimize angling impacts on adult steelhead spawners and outmigrating smolts, redband trout angling in the Walla Walla subbasin where anadromous fish are present is open from the fourth Saturday in May through October 31, with an eight-inch minimum length. The fishery through the summer and fall is focused on resident trout (eight-inch minimum length) rather than younger fish, which could be either resident or anadromous juveniles. All waterways in the subbasin are open to fishing for redband trout during the appropriate season. There are no closed areas.

Significant protection for juvenile steelhead and bull trout is also being provided under the current fisheries regulations. Fisheries for redband trout in the Walla Walla subbasin have been adapted to protect wild *O. mykiss* in natural production areas. Anglers have been restricted to the use of flies and lures in the South Fork since 1996 and in Walla Walla River and tributaries since 1999. The daily bag limit is five fish over eight inches in length.

Legal-sized hatchery rainbow trout have been historically stocked in many streams throughout the Walla Walla subbasin in Oregon. In 1994, all stocking of hatchery rainbow trout was discontinued in streams within the Oregon portion of the Walla Walla subbasin to protect wild stocks of *O. mykiss* and bull trout.

Fishing effort is currently much lower than in previous years because of the elimination of hatchery catchable trout stocking in the Walla Walla River and the conservative, selective fishing regulations currently in place. It is difficult to quantify the impacts to juvenile steelhead from sportfishing because of the lack of information specific to the Walla Walla River. However, given the current regulations that are in place for juvenile steelhead, the dispersed nature of the fishery and cessation of trout stocking, it is estimated that <1% or rearing juvenile steelhead in the Walla Walla River subbasin are caught and released in the trout fishery.

8.6 Hatchery Practices and Releases

This section describes potential hatchery-related limiting factors for Mid-C steelhead populations in the Fifteenmile, Deschutes, John Day, Umatilla and Walla Walla rivers systems.

8.6.1 Overview

Two hatchery programs are operated within the Mid-C DPS in Oregon, the Round Butte Hatchery program in the Deschutes River and the Umatilla Hatchery program in the Umatilla River. In addition WDFW releases hatchery smolts into the Walla Walla population as part of the Lower Snake River Compensation Plan program. The Mid-C Expert Panel expressed particular concern regarding the continuing detrimental impact of stray out-of-DPS hatchery fish in natural spawning areas on the genetic traits and productivity of naturally produced Mid-C steelhead. They also concluded that the spawning of hatchery produced adult steelhead from programs in the Umatilla and Walla Walla subbasins with naturally produced fish in these and other drainages adversely affects the population traits (productivity, genetic traits, and adult abundance) of the steelhead populations. Round Butte Hatchery in the Deschutes subbasin also

produces steelhead; however, the risks from this hatchery program to naturally spawning populations are considerably less than those from the other programs.

8.6.2 Fifteenmile Creek Steelhead

ODFW stocked rainbow trout in Fifteenmile Creek at the Taylorville Bridge until 1974 and at the downtown Dufur Bridge until 1991; and in Mosier Creek from 1952-1963 and 1968-1971. Today, hatchery fish are only stocked in Hanel Lake that has been stocked annually since 1994 with approximately 500 catchable coastal rainbow trout from a private hatchery/trout farm near Sandy, Oregon or Oak Springs Fish Hatchery. A screen in the Wolf Run Ditch prevents the stocked fish from migrating out of the reservoir.

Interbreeding between hatchery rainbow trout and steelhead in Fifteenmile Creek is believed to have been minimal. The particular stock of rainbows used for these introductions is not believed to have survived the summer due to susceptibility to a naturally occurring disease (*Ceratomyosis*), to which native rainbow are resistant.

Currently, there are no plans to use artificial propagation to augment fisheries or enhance natural production in the Fifteenmile Creek subbasin any time in the future. Consequently, the main hatchery-related threat to the Fifteenmile steelhead population is from out-of-subbasin strays. There have been very few stray hatchery steelhead observed in Fifteenmile Creek and there are few likely sources of winter steelhead strays in the Mid-Columbia DPS. Stray hatchery fish were not identified as a risk in the viability assessment.

8.6.3. Deschutes River Steelhead

Round Butte Hatchery
Round Butte Hatchery (RBH) currently produces and releases steelhead in the Deschutes as mitigation for loss of habitat and harvest opportunities due to the construction of the Round Butte Complex of hydroelectric dams. The goal of the program is to produce 1,800 adults returning to the project. The RBH summer steelhead program is limited to known RBH stock to prevent the propagation of out-of-subbasin fish and associated disease concerns. Natural-origin fish were incorporated into the broodstock during the 1990–1998 brood years, but the practice was discontinued due to concerns about introducing or propagating diseases borne by unmarked fish of unknown origin from outside the subbasin. All RBH steelhead not used for broodstock and all out-of-subbasin hatchery fish are removed from the river at Pelton Trap and Warm Springs National Fish Hatchery (WSNFH).

The RBH program minimizes impacts to naturally produced summer steelhead by releasing juveniles as age 1+ smolts, and at sizes and times that support rapid migration from the subbasin. This limits the potential for competitive interactions. RBH steelhead are acclimated at the hatchery before release to improve homing back to the hatchery. As a result, competitive interactions with wild juvenile steelhead in overwintering or rearing habitat are believed to be low. Resident *O. mykiss* naturally exist at multiple ages and at relatively great densities in parts of the Deschutes River and co-exist with other native salmonids including natural steelhead. This acclimation and homing of the RBH steelhead has been effective; in recent years less than 1% of

the steelhead observed at the WSNFH have been of RBH origin. RBH summer steelhead are uniquely marked to allow for their harvest and removal in selective recreational fisheries and to allow for identification during broodstock collection activities.

Out-of-Subbasin Strays

The large number of out-of-subbasin hatchery steelhead straying into the Deschutes River each year presents a major risk to the population. In recent years, out-of-subbasin hatchery steelhead collected and removed at WSNFH and the Pelton Trap averaged over 30% of the returns. The Mid-C Expert Panel considered strays a primary threat to Deschutes steelhead populations.

The number of out-of-subbasin hatchery-origin steelhead observed in the Deschutes River began to increase as mitigation programs developed in other Columbia Basin watersheds (Figure 8-18 and Table 8-55). A majority of these fish were produced in the Snake River Basin under the Lower Snake River Compensation Program, with a relatively large proportion of the out-of-subbasin stray steelhead originating from the Wallowa Hatchery program (Carmichael and Hoffnagle 2006; Olson and Spateholz, no date). At WSNFH, where all steelhead known to be artificially produced are removed from the natural-origin population that is allowed to pass upstream, RBH steelhead make up a small proportion of the fish collected at the trap (Table 8-56).

Hatchery-origin steelhead have been observed spawning with unmarked steelhead in Deschutes River tributaries, and both live and dead hatchery-origin steelhead have been observed during spawning ground surveys in Bakeoven and Buck Hollow creeks (Table 8-57). However, the fish are not handled and stock composition of hatchery-origin steelhead is unknown. Stock composition of hatchery-origin fish that ascend Sherars Falls (the trapping facility nearest Bakeoven and Buck Hollow creeks) is monitored in terms of the proportion of Round Butte Hatchery steelhead relative to hatchery fish that originate from outside the subbasin, but the rate at which out-of-subbasin fish that ascend the falls remain within the Deschutes and spawn among the native populations is not well known. The trend in abundance of hatchery-origin fish within Bakeoven and Buck Hollow creeks has appeared to follow that at Sherars Falls, but at an overall lower rate. Most hatchery fish observed on the spawning grounds are out-of-subbasin strays.

Out-of-DPS hatchery strays comprised an average of 29% of the Westside population and 15.2% of the Eastside population over the past three generations. This high fraction resulted in high risk ratings for spawner composition for both populations as described in the viability assessment.

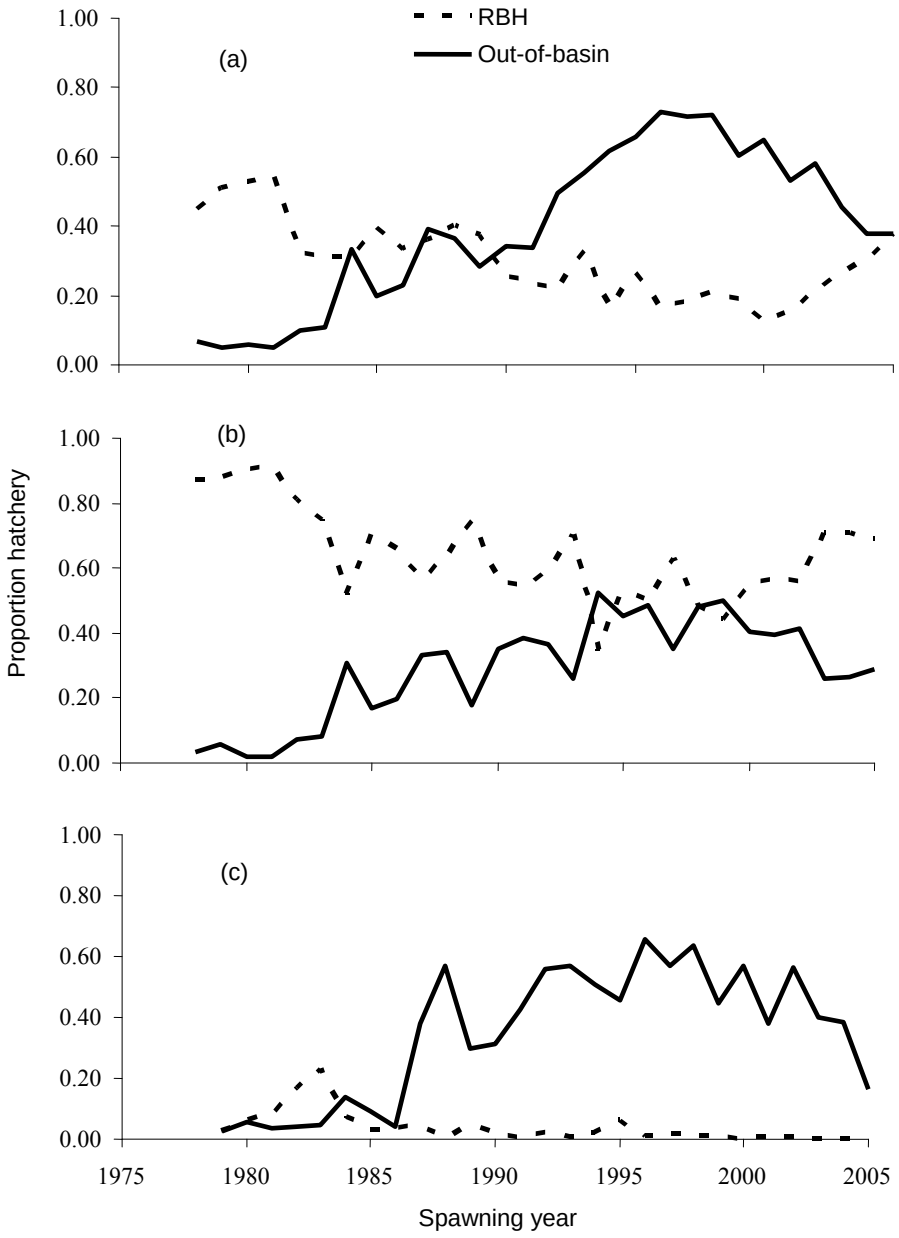


Figure 8-18. Proportion of steelhead that are Round Butte Hatchery and out-of-subbasin hatchery origin by trapping facility: (a) Sherars Falls, (b) Pelton Trap, (c) WSNFH.

Table 8-55. Number of steelhead by origin in the Deschutes River by year and trapping facility, 1977 - 2004.

		Estimated Escapement of Steelhead at Sherars Falls				*Steelhead at Pelton Trap*				*Steelhead at Warm Springs NFH*			
Return year	Brood year	Wild	Round Butte Hatchery	Out-of-subbasin hatchery	Total	Wild	Round Butte Hatchery	Out-of-subbasin hatchery	Total	Wild	Round Butte Hatchery	Out-of-subbasin hatchery	Total
1977	1978	6,556	6,121	900	13,577	233	2,120	80	2,433	336			336
1978	1979	2,759	3,184	300	6,243	136	1,732	110	1,978	290	8	8	306
1979	1980	4,204	5,400	600	10,204	223	2,612	54	2,889	311	22	20	353
1980	1981	4,100	5,500	500	10,100	169	2,195	47	2,411	397	36	15	448
1981	1982	6,900	3,800	1,200	11,900	245	1,760	156	2,161	569	122	31	722
1982	1983	6,567	3,524	1,249	11,340	344	1,547	167	2,058	255	82	16	353
1983	1984	8,228	7,250	7,684	23,162	814	2,439	1,452	4,705	431	40	75	546
1984	1985	7,721	7,563	3,824	19,108	603	3,278	795	4,676	577	22	62	661
1985	1986	9,624	7,382	5,056	22,062	686	3,153	943	4,782	373	15	16	404
1986	1987	6,207	9,064	9,803	25,074	467	2,640	1,538	4,645	822	60	545	1,427
1987	1988	5,367	9,209	8,367	22,943	46	1,484	796	2,326	522	4	695	1,221
1988	1989	3,546	3,849	2,909	10,304	123	1,247	300	1,670	385	28	177	590
1989	1990	4,278	2,758	3,659	10,695	136	829	524	1,489	339	10	157	506
1990	1991	3,653	1,990	2,852	8,495	82	606	428	1,116	165	2	123	290
1991	1992	4,826	3,778	8,409	17,013	101	1,365	849	2,315	280	14	374	668
1992	1993	904	2,539	4,261	7,704	59	1,157	427	1,643	82	1	109	192
1993	1994	1,487	1,159	4,293	6,939	74	190	288	552	135	6	146	287
1994	1995	482	1,781	4,391	6,654	27	753	642	1,422	93	12	88	193
1995	1996	1,662	2,708	11,855	16,225	32	1,000	976	2,008	87	3	171	261
1996	1997	3,458	5,932	23,618	33,008	126	3,605	2,001	5,732	239	8	327	574
1997	1998	1,820	5,042	17,703	24,565	194	2,440	2,459	5,093	218	6	388	612
1998	1999	3,800	3,527	11,110	18,437	155	1,135	1,284	2,574	97	2	79	178
1999	2000	4,790	2,628	13,785	21,203	83	1,050	768	1,901	322	0	422	744
2000	2001	8,985	4,380	15,072	28,437	114	1,593	1,103	2,810	513	3	316	832
2001	2002	8,749	9,373	25,263	43,385	282	4,942	3,674	8,898	733	12	971	1,716
2002	2003	9,363	8,880	15,203	33,446	207	4,841	1,787	6,835	877	0	582	1,459
2003	2004	5,524	5,265	6,542	17,331	104	2,605	967	3,676	286	0	178	464
2004	2005	3,161	4,942	4,949	13,052	79	2,143	903	3,125	327	1	64	392

Table 8-56. Proportions of steelhead by origin in the Deschutes River by year and trapping facility, 1977 - 2004.

		Estimated Escapement at Sherars			*Pelton Trap*			*Warm Springs NFH*		
Return year	Spawning year			Out-of-subbasin			Out-of-subbasin			Out-of-subbasin
1977	1978	Wild 0.48	RBH 0.45	0.07	Wild 0.10	RBH 0.87	0.03	Wild 0.95	RBH 0.03	0.03
1978	1979	0.44	0.51	0.05	0.07	0.88	0.06			
1979	1980	0.41	0.53	0.06	0.08	0.90	0.02	0.88	0.06	0.06
1980	1981	0.41	0.54	0.05	0.07	0.91	0.02	0.89	0.08	0.03
1981	1982	0.58	0.32	0.10	0.11	0.81	0.07	0.79	0.17	0.04
1982	1983	0.58	0.31	0.11	0.17	0.75	0.08	0.72	0.23	0.05
1983	1984	0.36	0.31	0.33	0.17	0.52	0.31	0.79	0.07	0.14
1984	1985	0.40	0.40	0.20	0.13	0.70	0.17	0.87	0.03	0.09
1985	1986	0.44	0.33	0.23	0.14	0.66	0.20	0.92	0.04	0.04
1986	1987	0.25	0.36	0.39	0.10	0.57	0.33	0.58	0.04	0.38
1987	1988	0.23	0.40	0.36	0.02	0.64	0.34	0.43	0.00	0.57
1988	1989	0.34	0.37	0.28	0.07	0.75	0.18	0.65	0.05	0.30
1989	1990	0.40	0.26	0.34	0.09	0.56	0.35	0.67	0.02	0.31
1990	1991	0.43	0.23	0.34	0.07	0.54	0.38	0.57	0.01	0.42
1991	1992	0.28	0.22	0.49	0.04	0.59	0.37	0.42	0.02	0.56
1992	1993	0.12	0.33	0.55	0.04	0.70	0.26	0.43	0.01	0.57
1993	1994	0.21	0.17	0.62	0.13	0.34	0.52	0.47	0.02	0.51
1994	1995	0.07	0.27	0.66	0.02	0.53	0.45	0.48	0.06	0.46
1995	1996	0.10	0.17	0.73	0.02	0.50	0.49	0.33	0.01	0.66
1996	1997	0.10	0.18	0.72	0.02	0.63	0.35	0.42	0.01	0.57
1997	1998	0.07	0.21	0.72	0.04	0.48	0.48	0.36	0.01	0.63
1998	1999	0.21	0.19	0.60	0.06	0.44	0.50	0.54	0.01	0.44
1999	2000	0.23	0.12	0.65	0.04	0.55	0.40	0.43	0.00	0.57
2000	2001	0.32	0.15	0.53	0.04	0.57	0.39	0.62	0.00	0.38
2001	2002	0.20	0.22	0.58	0.03	0.56	0.41	0.43	0.01	0.57
2002	2003	0.28	0.27	0.45	0.03	0.71	0.26	0.60	0.00	0.40
2003	2004	0.32	0.30	0.38	0.03	0.71	0.26	0.62	0.00	0.38
2004	2005	0.24	0.38	0.38	0.03	0.69	0.29	0.83	0.00	0.16
	Minimum	0.07	0.12	0.05	0.02	0.34	0.02	0.33	0.00	0.03
	Maximum	0.58	0.54	0.73	0.17	0.91	0.52	0.95	0.23	0.66
	Average	0.30	0.30	0.39	0.07	0.64	0.29	0.62	0.04	0.34

Table 8-57. Proportion of hatchery-origin fish by location in the lower Deschutes Subbasin (for N > 9).

		Buck Hollow			Bakeoven			Trout Creek		
Return year	Spawning year	Marked	Unmarked	Hatchery fraction	Marked	Unmarked	Hatchery fraction	Marked	Unmarked	Hatchery fraction
1989	1990	2	14	0.125	1	2	N/A	--	--	--
1990	1991	2	4	N/A	0	5	N/A	--	--	--
1991	1992	1	9	0.100	0	0	N/A	--	--	--
1992	1993	2	1	N/A	3	2	N/A	--	--	--
1993	1994	1	1	N/A	0	0	N/A	--	--	--
1994	1995	11	11	0.500	3	1	N/A	--	--	--
1995	1996	11	7	0.611	8	2	0.800	--	--	--
1996	1997	23	9	0.719	9	4	0.692	--	--	--
1997	1998	26	1	0.963	2	3	N/A			0.250
1998	1999	14	15	0.483	6	13	0.316			0.390
1999	2000	8	8	0.500	17	14	0.548			0.500
2000	2001	23	108	0.176	29	167	0.148	--	--	--
2001	2002	20	42	0.323	10	55	0.154	--	--	--
2002	2003	17	43	0.283	4	19	0.174	9	48	0.158
2003	2004	33	30	0.524	5	8	0.385	0	8	0.000
2004	2005	2	12	0.143	0	4	N/A	1	85	0.012
	Average			0.419			0.402			0.218

Potential Inter-Specific Hatchery Interactions

Two spring Chinook salmon hatchery programs exist in the Deschutes River subbasin, one at Warm Springs NFH and one at Round Butte Hatchery, to mitigate for lost habitat and harvest opportunities due to construction and operation of the Pelton-Round Butte Complex. Spring Chinook salmon occur naturally in the Warm Springs River and Shitike Creek. Spring Chinook salmon are reared as juveniles to age 1+ smolts. Smolts actively migrate downstream after release, thus the duration of time that negative interactions could occur with native steelhead juveniles is relatively short. Interactions in overwintering and other rearing habitat are thought to be minimal. Bacterial Kidney Disease occurs within the Round Butte Hatchery broodstock. The influence of the Chinook hatchery programs is minimal and of little concern.

8.6.4 John Day River Steelhead

The John Day River steelhead populations are currently managed entirely as wild populations. No hatchery production or supplementation occurs within the John Day River subbasin. Hatchery releases of summer and winter run steelhead occurred historically in the John Day River subbasin between 1925 and 1969 (Table 8-58). Hatchery steelhead were last released into the John Day River subbasin in 1969. Hatchery steelhead released between 1966 and 1969 were for experimental use only and were not meant for production purposes (ODFW 1990, Olsen et al. 1994).

Table 8-58. Year, run (W-winter, S-summer, U-unknown), number, tributary, and subbasin of release for all known hatchery steelhead released into the John Day River subbasin from 1925 - 1969.

Year	Run	Number	Tributary	Subbasin
1925	U	16,080	Canyon Creek	Upper Mainstem
1941	U	8,760	Canyon Creek	Upper Mainstem
1947	U	7,600	Rock Creek	Lower Mainstem
1947	U	7,520	Thirtymile Creek	Lower Mainstem
1962	W	200,000	Camas Creek	North Fork
1962	W	375,000	Granite Creek	North Fork
1963	U	10,667	Mainstem	Mainstem
1964	W	10,198	Upper Mainstem	Upper Mainstem
1965	W	27,860	South Fork	South Fork
1966	S	55,518	Middle Fork	Middle Fork
1967	S	98,090	Upper Mainstem	Upper Mainstem
1967	S	71,500	Camas Creek	North Fork
1969	S	22,375	Bridge Creek	Middle Fork

Rainbow trout make up the majority of all hatchery fish species released into the John Day River subbasin (Table 8-59). The mean annual stocking rate of hatchery *O. mykiss* in the John Day River subbasin between 1925 and 1997 was 71,402 fish and ranged between 5,000 and 612,668 fish. Concern over competition for resources with wild fish and potential hybridization with natural-origin fish resulted in termination of all hatchery stocking of *O. mykiss* in the John Day River subbasin in 1997.

Table 8-59. Summary of all known stocking records for hatchery salmonids released into the John Day River subbasin from 1925-1997. Species include rainbow trout (RbT), steelhead of unknown run (Sthd), winter steelhead (StW), summer steelhead (StS), brook trout (BkT), and west slope cutthroat trout (WcT).

Summary of Stocking Records for Hatchery Salmonids Released in John Day River Subbasin, 1925-1997.

Year	RbT	Sthd	StW	StS	Coho	BkT	WcT	Total releases
1925	77,000	16,080			25,000			118,080
1926	25,680				45,000	42,745		113,425
1927	6,000							6,000
1928	43,000				27,530			70,530
1929	293,000							293,000
1930					50,000			50,000
1931	5,000				10,000			15,000
1932								0
1933	70,000				8,050			78,050
1934	31,000							31,000
1935								0
1936								0
1937								0
1938								0
1939								0
1940	92,206				50,268			142,474
1941	66,930	8,760						75,690
1942	36,632							36,632
1943	16,763							16,763
1944	31,050							31,050
1945	16,080							16,080
1946	36,960							36,960
1947	254,025	15,120						269,145
1948	66,025							66,025
1949	10,290							10,290
1950	52,343							52,343
1951	14,560							14,560
1952	21,808							21,808
1953	24,376							24,376
1954	36,946							36,946
1955	58,783							58,783
1956	57,297							57,297
1957	43,206							43,206
1958	71,272							71,272
1959	41,727							41,727
1960	41,498							41,498
1961	29,980							29,980
1962	37,668		575,000					612,668
1963	38,931	10,667						49,598
1964	17,508		10,200					27,708
1965	72,598		27,860				199	100,657
1966	174,305			55,518		325,793	59,425	615,041
1967	141,210			170,500				311,710
1968	24,493							24,493
1969	325,185			22,375				347,560
1970	184,227							184,227

Summary of Stocking Records for Hatchery Salmonids Released in John Day River Subbasin, 1925-1997.

Year	RbT	Sthd	StW	StS	Coho	BkT	WcT	Total releases
1971	31,547							31,547
1972	60,093							60,093
1973	141,758							141,758
1974	84,809							84,809
1975	87,850							87,850
1976	84,121							84,121
1977	85,173							85,173
1978	110,521							110,521
1979	148,294							148,294
1980	95,565							95,565
1981	87,480							87,480
1982	106,053							106,053
1983	111,964							111,964
1984	46,567							46,567
1985	57,715							57,715
1986	64,226							64,226
1987	8,997							8,997
1988	43,572							43,572
1989	29,369							29,369
1990	32,987							32,987
1991	21,036							21,036
1992	21,043							21,043
1993	8,004							8,004
1994	22,525							22,525
1995	7,993							7,993
1996	6,988							6,988
1997	6,479							6,479

Out-of-Subbasin Strays

Out-of-subbasin hatchery steelhead strays pose a significant and primary threat to John Day steelhead populations. The Mid-C Expert Panel identified out-of-DPS hatchery strays as a threat to population traits for the Lower Mainstem population. Most hatchery stray recoveries occur in the Lower Mainstem below the North Fork (Table 8-60); however, strays have been observed in all populations. Carmichael et al. (2006) reports that the proportion of hatchery spawners in the Lower Mainstem population ranged from 0.01 in the early 1990's to 0.18 in 2004, with a mean of 0.07. The ICTRT considers this to be a high risk for the metric of spawner composition because of the increasing trend since the 1990's, fraction of strays and origin of the strays (Carmichael et al. 2006). Carmichael et al. (2006) concluded that all five of the John Day steelhead populations were at high risk for the John Day spawner composition viability metric. Data from coded-wire tagged hatchery steelhead recovered between 1986 and 2003 indicate that a large portion of the hatchery fish were from Wallowa stock releases into the Grande Ronde Rivers; however, most hatchery fish from upper Columbia River tributaries are not coded-wire tagged.

Hatchery steelhead coded-wire tag (CWT) recoveries in the John Day subbasin from 1986 to 2003 (378 recoveries) identify 18 separate hatcheries as the sources of strays. The majority of CWT recoveries were located downstream of Tumwater Falls in the John Day Arm (316

recoveries) and may not accurately represent fish that stayed and spawned within the John Day subbasin. The recoveries indicate that Dworshak National Hatchery is the predominate source of hatchery steelhead strays in the lower portion of the subbasin (97 CWT recoveries; 31%). Between Tumwater Falls and Cottonwood Bridge (RM 40) 55 hatchery CWT recoveries have been reported with many recoveries (26 CWT recoveries; 47%) in this area identifying Irrigon Hatchery (fish primarily released in the Grande Ronde Subbasin) as the source of strays (Table 8-61). Limited information is available upstream of Cottonwood Bridge with only seven hatchery CWT recoveries reported. Irrigon Hatchery was the source of two hatchery steelhead strays in this area. It should be noted that the probability of observation of strays in the John Day River from any particular hatchery stock is dependent on the survival, stray rate of that stock, and the number of individuals tagged from the stock. There is substantial difference in numbers of fish tagged between stocks, and in some cases no hatchery fish are marked with CWTs.

Table 8-60. Hatchery source, stock, number recovered, recovery period, and release agency for hatchery steelhead with coded wire tags in the John Day River arm. (Tumwater Falls upstream to Cottonwood Bridge) from 1996-2003. Data were compiled from the Pacific States Marine Fishery Commission Regional Mark Information System.

Hatchery Source	Stock	Number Recovered	Recovery Period	Release Agency
Irrigon	Wallowa R., Imnaha R. & tributaries	25	10/10 - 05/07	ODFW
Cottonwood Creek Pond	Wallowa R.	10	10/11 - 05/23	WDFW
Magic Valley	Pahsimeroi R. 'A' run, Dworshak 'B' run, East Fork Salmon R. 'B' run	5	10/27 - 01/31	IDFG
Niagara Springs	Pahsimeroi R. 'A' run, Hells Canyon 'A' run	5	10/20 - 01/24	IDFG
Clearwater	Dworshak 'B' run	2	01/09 - 02/10	IDFG
Dworshak National	Dworshak 'B' run	2	10/17 - 02/09	FWS
Umatilla	Umatilla R.	2	10/09 - 11/11	ODFW

Table 8-61. Hatchery source, release location, recovery location, number recovered, and recovery year for hatchery steelhead with coded wire tags in the John Day River above Cottonwood Bridge (RM 40) from 1988-2003. Data were compiled from archives in the John Day Field Office and Wilson et al. (2004).

Hatchery Source	Release Location	Recovery Location	Number Recovered	Recovery Year
Big Canyon	Unknown	Lower North Fork	1	1994
Irrigon	Spring Creek of Wallowa R., OR	Kahler Creek, Lower Mainstem	1	2003
Irrigon	Big Canyon Creek of Wallowa R., OR	Service Creek, Lower Mainstem	1	2003
Cottonwood Creek Pond	Grande Ronde R., OR	Service Creek, Lower Mainstem	1	2003
Unknown Washington Hatchery	Unknown	Service Creek, Lower Mainstem	1	2003
Upper Columbia	Unknown	Cottonwood Bridge to Little Ferry Canyon	1	1988
Wallowa	Unknown	Lower North Fork	1	1992

Distribution of Hatchery and Natural Adults
Most observations of hatchery adults in the John Day have occurred in the Lower Mainstem, below the confluence with the North Fork (Wiley et al. 2004). However, several reports have noted observations of fin-clipped fish in the North Fork and South Fork drainages. These observations come from both spawning ground surveys and creel programs.

Claire and Gray (1992a) reported 17 (23%) adipose fin clipped steelhead of 75 caught upstream of Kimberly (RM 185) during the 1992 steelhead fishery. Within the 1992 Zone 3 summer steelhead fishery (Kimberly to Indian Creek), 16% (6 of 37) of the fish reported by anglers were of hatchery origin (Claire and Gray 1992a). Within the 1992 lower North Fork summer steelhead fishery, 29% (11 of 37 reported) of steelhead reported by anglers were of hatchery origin. Claire and Gray (1992a) did not provide an explanation for the high stray rates observed during the 1992 fishery. Wilson et al. (2001) reported observing thirteen adipose fin-clipped adult summer steelhead (46%, both live and as carcasses) of twenty-eight steelhead observed while seining for smolts in the Mainstem John Day River between Kimberly (RM 185) and Spray (RM 170).

Wiley et al. (2004) observed 50, live adult steelhead and sampled five carcasses on spawner surveys conducted during 2004. Of the ten sites where live fish were observed they were able to identify 34 fish as hatchery or wild at six of those sites based upon the presence (hatchery) or absence (wild) of an adipose fin clip (fin mark). Hatchery steelhead (13 fish) comprised 38% of live fish observations and were found at two of the six sites where identifications could be made. The majority of live hatchery steelhead observed (12 fish; 92%) and hatchery carcasses sampled (3 fish; 100%) during spawner surveys came from one stream (Service Creek) located in the Lower Mainstem at RM 157. An additional live hatchery steelhead was also observed in the Lower Mainstem in Rock Creek. They estimated 3,726 wild and 2,284 hatchery steelhead were present during the spawning season based upon the wild:hatchery ratio of live fish observed during spawner surveys.

Wiley et al. (2004) observed fin-clipped adults paired with wild adults on redds during 2004. Others have also observed hatchery origin fish paired with wild fish during spawning (Wilson et al. 2004). Observations of pairings between hatchery and wild fish on the spawning grounds indicate introgression. No evidence is available for any negative impacts resulting from interactions between hatchery and natural steelhead in the John Day River subbasin.

8.6.5 Umatilla River Steelhead

The Umatilla River summer steelhead program was designed to enhance the natural production through supplementation and to provide sustainable harvest in the Umatilla River subbasin. The annual production goal is for a release of 150,000 smolts. Smolts are adipose fin-clipped to allow for selective fisheries and to monitor returns to TMFD. The program is funded by BPA through the NPCC Fish and Wildlife Program.

Several ongoing management actions were implemented to limit potential negative impacts on wild steelhead from the hatchery program. These actions all have positive benefits, and include 1) marking hatchery produced steelhead to limit fishing mortality on wild steelhead, 2) reading

coded-wire tags before spawning broodstock to prevent using out-of-subbasin strays, and 3) acclimating and releasing a portion of hatchery smolts near areas targeted for supplementation and a portion lower in the subbasin to increase fishing opportunities in the lower river. Releasing a portion of the adults in the lower river also has the potential to limit spawning interactions between hatchery and wild adults. Nevertheless, the existing hatchery programs for steelhead and coho in the subbasin continue to pose potential risks to the wild steelhead population. However, the Mid-C Expert Panel did not identify hatchery fish as a primary threat to the population.

Hatchery Program History

The first attempt to supplement the natural population of summer steelhead in the Umatilla River and tributaries was in 1967 when hatchery-produced, non-endemic steelhead from Skamania and Idaho (Oxbow) stocks were released in the Umatilla River (ODFW 1987). From 1968 through 1970, only non-endemic Skamania stock steelhead were released into the Umatilla River. No hatchery-produced steelhead were released in the Umatilla River from 1971 through 1974. The early release numbers and size-at-release varied considerably (Table 8-62). The first release of smolts from endemic Umatilla stock occurred in 1975. There were no releases of hatchery-produced steelhead from 1976 through 1980. Annual releases of smolts from endemic Umatilla stock ensued from 1981 to the present.

Broodstock are currently collected from returns to the Three Mile Falls Dam (TMFD) trap on the Umatilla River (RM 3.7). The broodstock goal is 120 adults, including 10 pairs of coded-wire tagged program fish. Steelhead are transferred to the Minthorn acclimation site for holding and spawning. The coded-wire tags are read prior to spawning to insure out-of-subbasin hatchery fish are not used for broodstock. Spawning is performed using a 3x3 matrix, selecting for natural x natural crosses whenever possible, and no hatchery x hatchery crosses are used. Hatchery fish are used when there are not enough natural-origin fish to meet egg-take objectives.

Run Composition

Steelhead returns to TMFD have averaged 956 hatchery, and 1,668 natural fish from the 1992-93 through 2003-04 run years (Table 8-63). Over the same time period, Umatilla hatchery steelhead comprised 23.9-52.0% of the run (mean 32.0%), while out-of-subbasin hatchery steelhead comprised 2.1-10.1% of the run (mean 3.1%; Table 8-63). Some steelhead are removed at TMFD for broodstock while others are harvested upstream in tribal and non-tribal recreational fisheries. Umatilla hatchery steelhead have comprised 19.0-57.1% of steelhead available to spawn in nature (mean 29.4%), and out-of-subbasin hatchery steelhead have comprised 1.8-9.7% of potential spawners (mean 4.8%; Table 8-64). Carmichael (2000) concluded that the Umatilla River population was at high risk for the spawner composition viability metric. This high risk rating was the result of a moderate risk rating for proportion of out-of-DPS strays and a moderate risk rating for within-population hatchery spawners.

Table 8-62. Releases of summer steelhead in the Umatilla River subbasin prior to the current program at Umatilla Fish Hatchery (Chess et al. 2003a).

Release Year	Hatchery	No. Released	Fish/lb.	Strategy	Stock	Acclimation Facility	Direct-release
1967	Gnat Creek	109,805	75	Subyearling	Skamania		
1967	Oak Springs	238,020	117	Subyearling	Oxbow		
1967	Wallowa	142,240	240	Subyearling	Oxbow		
1968	Gnat Creek	23,100	66	Subyearling	Skamania		
1968	Gnat Creek	150,000	Eggs	eggs	Skamania		
1969	Oak Springs	174,341	145	Subyearling	Skamania		
1970	Carson	39,489	8.0-9.0	Yearling	Skamania		
1975	Wizard Falls	11,094	9	Yearling	Umatilla		
1981	Oak Springs	17,558	6.0-9.0	Yearling	Umatilla		Upper Umat. R.
1981	Oak Springs	9,400	145	Subyearling	Umatilla		Upper Umat. R.
1982	Oak Springs	59,494	7.0-8.0	Yearling	Umatilla		Upper Umat. R.
1982	Oak Springs	67,940	124	Subyearling	Umatilla		Upper Umat. R.
1983	Oak Springs	60,500	11	Yearling	Umatilla		Upper Umat. R.
1983	Oak Springs	52,700	62	Subyearling	Umatilla		Upper Umat. R.
1984	Oak Springs	57,939	6.5	Yearling	Umatilla		Upper Umat. R.
1984	Oak Springs	22,000	135	Subyearling	Umatilla		Upper Umat. R.
1985	Oak Springs	53,850	7	Yearling	Umatilla		Upper Umat. R.
1985	Oak Springs	39,134	150	Subyearling	Umatilla		Upper Umat. R.
1986	Oak Springs	54,137	8.4	Yearling	Umatilla	Bonifer Spr.	
1987	Oak Springs	1,485	5.5	Yearling	Umatilla		
1988	Oak Springs	30,549	7.4	Yearling	Umatilla	Minthorn Spr.	
1988	Oak Springs	30,757	6.5	Yearling	Umatilla		Umat. R. Minthorn
1988	Oak Springs	33,984	10.3	Yearling	Umatilla		Umat. R. Stanfield
1988	Oak Springs	10,033	57.5	Subyearling	Umatilla		Umat. R. Corporation
1988	Irrigon	24,618	3,200	unfed fry	Umatilla		S. Fk. Umatilla R.
1989	Oak Springs	29,852	6.6	Yearling	Umatilla	Minthorn Spr.	
1989	Oak Springs	29,586	5.6	Yearling	Umatilla		Umat. R. at Minthorn
1990	Oak Springs	30,225	5.9	Yearling	Umatilla	Bonifer Spr.	
1990	Oak Springs	29,446	5.5	Yearling	Umatilla		Meacham Cr. (mouth)
1991	Oak Springs	30,221	6.2	Yearling	Umatilla	Bonifer Spr.	
1991	Oak Springs	29,325	8.7	Yearling	Umatilla		Meacham Cr. (mouth)
1992	Umatilla	67,435	5.8	Yearling	Umatilla	Bonifer/Minthorn	
1992	Umatilla	64,550	5	Yearling	Umatilla		Meacham Cr. (mouth)
1992	Umatilla	67,419	5.5	Yearling	Umatilla		Meacham Cr. (mouth)

Table 8-63. Percent of Umatilla and non-endemic hatchery returns to Three Mile Falls Dam.

Run Year	Umatilla Hatchery Return to TMFD	% Umatilla Hatchery Return to TMFD	Non-Endemic Hatchery Return to TMFD	Prop Non-Umatilla Hatch. Return to TMFD	Total Hatchery Return To TMFD	Natural Return to TMFD	Total Hat+Nat Return to TMFD
92-93	490	25.6%	126	6.6%	616	1298	1914
93-94	309	24.0%	36	2.8%	345	945	1290
94-95	535	34.9%	122	8.0%	657	874	1531
95-96	664	31.9%	121	5.8%	785	1296	2081
96-97	1288	52.0%	175	7.1%	1463	1014	2477
97-98	725	41.1%	178	10.1%	903	862	1765
98-99	701	37.2%	49	2.6%	750	1135	1885
99-00	690	23.9%	61	2.1%	751	2141	2892
00-01	939	25.6%	164	4.5%	1103	2559	3662
01-02	1585	28.7%	276	5.0%	1861	3658	5519
02-03	816	26.5%	142	4.6%	958	2121	3079
03-04	1088	32.1%	190	5.6%	1278	2111	3389
Mean	819	32.0%	137	5.4%	956	1668	2624

Table 8-64. Percent of Umatilla and non-endemic hatchery returns available to spawn in nature.

Brood Year	Umatilla Hatchery Potential Spawners	Umatilla Hatchery Percent of Total Pot. Spawners	Non-Endemic Hatchery Potential Spawners	Non-endemic Hatchery Percent of Total Pot. Spawners	Total Hatchery Potential Spawners	Natural Potential Spawners	Total Potential Spawners
93	345	21.9%	62	3.9%	407	1165	1572
94	204	19.0%	23	2.1%	227	847	1074
95	420	32.4%	95	7.3%	515	783	1298
96	522	28.8%	95	5.2%	617	1194	1811
97	1146	51.7%	155	7.0%	1301	914	2215
98	609	39.8%	149	9.7%	758	771	1529
99	538	33.7%	37	2.3%	575	1020	1595
00	543	20.7%	48	1.8%	591	2030	2621
01	774	23.1%	135	4.0%	909	2444	3353
02	1389	26.9%	241	4.7%	1630	3542	5172
03	688	24.4%	119	4.2%	807	2015	2822
04	942	30.3%	164	5.3%	1106	2003	3109
Mean	677	29.4%	110	4.8%	787	1561	2348

Distribution of Hatchery and Natural Adults

In 2003, 70.0% of the summer steelhead available to spawn (fish released above TMFD minus all harvest components) were natural origin, and during spawning surveys 68.9% of the spawning steelhead identified were natural-origin (Schwartz et al. 2005; Table 8-66).

Adult steelhead were trapped and counted at Birch Creek by ODFW from 1995 to 1999 (DeBano et el. 2004; Table 8-65). The fish were collected in a fish ladder trap on a diversion dam located approximately 1/4 mile downstream of the confluence of the East and West forks of Birch Creek. An estimated 60% of the adult steelhead that pass this location jump over the diversion dam and are not counted in the trap. In 1995-1996, ODFW biologists conducted a mark/recapture study that led to a total escapement estimate above the trap location of 358 natural-origin and 15 hatchery-origin fish for a total of 373. For that year, this accounted for approximately 30% of the natural-origin fish that were counted at TMFD on the Umatilla. Mark/recapture data in other years were insufficient to make an accurate escapement estimate. A significant proportion of spawners observed on spawning ground surveys from 2001-2004 were hatchery origin in some locations within the population (Schwartz et al. 2005; Table 8-66).

Table 8-65. Adult summer steelhead collected at the fish trap on Birch Creek (Tim Bailey, Oregon Department of Fish and Wildlife, personal communication, January 2001).

Run Year	Natural-origin	Hatchery-origin	% Hatchery	Total
1995-96	143	6	4	149
1996-97	109	6	5	115
1997-98	85	1	1	86
1998-99	73	0	0	73

Table 8-66. Visual observations of natural and hatchery summer steelhead during spawning ground surveys (from Schwartz et al. 2005).

Brood Year	Iskuulpa Creek		NF Meacham Creek		Camp Creek		Boston Canyon Creek		Buckaroo Creek		South Fork Umatilla		Total Observed		Three Mile Dam STS		STS Available To Spawn	
	Nat	Hatch	Nat	Hatch	Nat	Hatch	Nat	Hatch	Nat	Hatch	Nat	Hatch	Nat	Hatch	Nat	Hatch	Nat	Hatch
2001																		
n=	4	3	4	0	2	0	0	1	5	2	2	0	17	6	2563	1099	2455	905
%=	57.1	42.9	100.0	0.0	100.0	0.0	0.0	100.0	71.4	28.6	100.0	0.0	73.9	26.1	70.0	30.0	73.1	26.9
2002																		
n=	14	6	2	0	4	3	0	6	3	4	0	0	23	19	3651	1862	3500	1696
%=	70.0	30.0	100.0	0.0	57.1	42.9	0.0	100.0	43.9	57.1	0.0	0.0	54.8	45.2	66.2	33.8	67.4	32.6
2003																		
n=	17	10	5	0	5	0	0	5	4	0	5	2	36	17	2118	956	2017	865
%=	63.0	37.0	100.0	0.0	100.0	0.0	0.0	100.0	100.0	0.0	71.4	28.6	67.9	32.1	68.9	31.1	70.0	30.0
2004																		
n=	19	7	3	0	0	0	0	6	2	0	0	0	24	13	2111	1277	2007	1246
%=	73.1	26.9	100.0	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0	0.0	64.9	35.1	62.3	37.7	61.7	38.3

Similarity between Hatchery-Origin and Natural-Origin Fish

Hatchery summer steelhead are produced primarily from unmarked summer steelhead returning to the subbasin. All hatchery juveniles are released as one-year smolts, compared to natural-origin summer steelhead that emigrate primarily as two-year smolts, with some three- and four-year-old smolts. The adult return timing and relative monthly percent of hatchery and natural

steelhead returning overlap closely. No large-scale seasonal separation exists between natural and hatchery steelhead, however Chi-Square and Kolmolgorov-Smirnov tests reveal significant differences between natural and hatchery frequencies on a monthly scale for most years (Chess et al. 2003a). The female-to-male ratio of natural summer steelhead is higher than hatchery steelhead. Female summer steelhead comprised 69.3 ± 1.3% (mean ± SE) of the natural return for return years 1992-93 through 2001-02, whereas females comprised 57.3 ± 2.3% (mean ± SE) of the hatchery return for the same period (Chess et al. 2003a). Age structure of hatchery and natural steelhead is similar. For run years 1992-93 through 2001-02, natural female summer steelhead were 58.8 ± 4.8% (mean ± SE) one-salt, compared to 57.2 ± 5.1% (mean ± SE) one-salt for hatchery female steelhead (not significantly different: ANOVA, P = 0.82; Chess et al. 2003a). For the same years, natural male steelhead were 68.5 ± 5.1% (mean ± SE) one-salt compared to 74.6 ± 4.4% (mean ± SE) of the hatchery male returns (not significantly different: ANOVA, P = 0.37; Chess et al. 2003a).

Smolt Releases and Acclimation Sites

Umatilla hatchery steelhead have always been released as one-year-old smolts, and are currently released at approximately 4.5 fish per pound (FPP). From the mid 1980s to the present, Bonifer Springs Pond and the Minthorn Springs site have been consistently used for acclimating Umatilla River summer steelhead. Large-grade summer steelhead and small-grade steelhead were acclimated at Bonifer Springs from brood years 1992 to 1998, excluding 1995 when the small-grade steelhead were acclimated at the Thornhollow site (RM 73.5). Bonifer Springs Pond is located at the confluence of Boston Canyon and Meacham creeks, two miles above the confluence with the Umatilla River at RM 80. Bonifer Springs Pond was used to acclimate steelhead because it is a tributary of Meacham Creek, which was identified as a major component of the available summer steelhead habitat in the Umatilla River subbasin (CTUIR and ODFW 1990) and was targeted for steelhead supplementation. Large-grade steelhead were acclimated at the Minthorn Springs site from brood year 1992 to 1998. The Minthorn Springs site is located at RM 64.5 of the mainstem Umatilla River. Minthorn Springs is a large spring system connected to the Umatilla River and floodplain. For brood years 1999 to 2001, small-grade (pass A) steelhead were no longer acclimated at Bonifer Springs, instead smalls were acclimated at Minthorn Springs following acclimation and release of the large-grade steelhead. The second group of large-grade steelhead was acclimated at Bonifer Springs Pond. In an effort to increase smolt survival, co-managers decided to release some steelhead from Pendleton (RM 56), the most downstream acclimation site in the subbasin. From 2002 to present, ungraded steelhead were released in approximately equal numbers (approx. 30,000-50,000 ea.) from the Pendleton and Minthorn acclimation facilities, and direct stream released in Boston Canyon Creek near Bonifer Springs. Acclimated fish are held in ponds for 2-3 weeks, allowed to volitionally migrate for one week, and then forced out of the ponds.

Juvenile Migration Timing

Natural and hatchery steelhead show similar trends in out-migration timing, except for the earlier migration of natural fish (Chess et al. 2003a; Figure 8-19). Hatchery steelhead were released from acclimation sites in early and late April. Small-grade steelhead were reared an extra month in the hatchery, acclimated and released a month later than the large-grade steelhead. If the hatchery steelhead migrated out of the Umatilla River subbasin soon after release, then a distinct, bimodal distribution of hatchery out-migrants would be produced. This was the case for three of

four years. The 1999 out-migrant year was skewed, but unimodal for hatchery steelhead. Natural steelhead started migration earlier than the earliest release hatchery steelhead release date in all four years. A small percentage of natural and hatchery steelhead arrive in late May and early June. Natural and hatchery out-migrants are being detected at Three Mile Falls Dam during rising and falling limbs of the hydrograph.

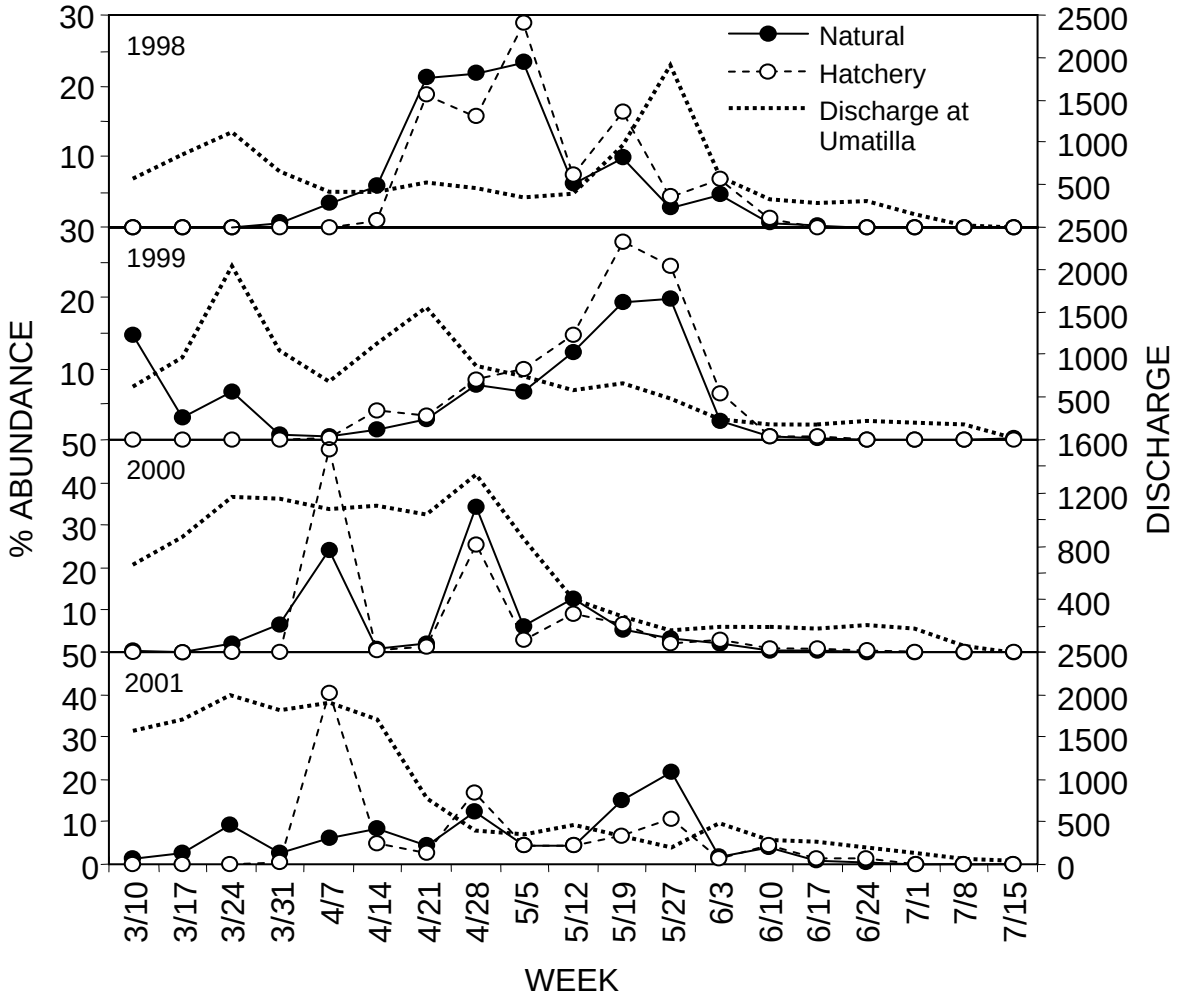


Figure 8-19. Migration timing of natural and hatchery summer steelhead smolts counted at Three Mile Falls Dam. The percentages were from weekly totals of fish divided by the respective total for the out-migration period. Daily Flow data at the lower Umatilla River gauge (RM 2.1) were averaged on a weekly interval (from Chess et al. 2003a).

Residualism

Steelhead, which were the smallest in the fall and were separated by grading for release in the spring, exhibited lower PIT tag detections at TMFD and lower smolt-to-adult survival, suggesting they either had lower out-migration survival or they were residualizing in the Umatilla River (Chess et al. 2003b). There was evidence that small-grade steelhead residualized and did not migrate until the second or third year following acclimation. Only 3 of 20 radio-tagged, small-grade steelhead migrated out of the subbasin after release from the outlet of Bonifer Springs (Stonecypher et al. 2001). Several detections of small-grade steelhead, PIT-tagged two years earlier have occurred at TMFD (White et al. 2003), confirming delayed out-migration of the small-grade production. Contor et al. (1995) estimated that 1,100 hatchery steelhead residualized in Boston Canyon Creek, with evidence of displacement of natural steelhead found in the stream. Approximately 4,000 hatchery steelhead residualize each year in Boston Canyon, Meacham, Minthorn Springs creeks, and in the mainstem Umatilla River (Contor et al. 1995). This estimate was 2.5% to 3.3% of the total steelhead released per year in the Umatilla River. There is evidence that many residual steelhead move into the lower Umatilla River. In recent years, anglers reported catching adipose and ventral fin clipped "trout" in the Stanfield area (RM 32). Summer steelhead are no longer size graded, all are released at approximately 4.5 FPP.

Other Salmonid Releases in the Umatilla Subbasin

Besides summer steelhead, coho salmon and spring and fall Chinook salmon are also released in the Umatilla River annually. Approximately 810,000 spring Chinook salmon are released annually, 600,000 from Umatilla hatchery and an additional 210,000 from Little White Salmon Hatchery (LWSH). All spring Chinook salmon are acclimated at the Imeques acclimation facility (RM 80). Fish raised at Umatilla Hatchery are transferred in fall or winter and released in mid-March at 12 FPP, whereas steelhead raised at LWSH are transferred to the acclimation site in mid-March and released in mid-April at 15 FPP. Approximately 1.5 million coho salmon are released in the Umatilla River annually. All coho salmon are acclimated at the Pendleton acclimation facility and released at 15 FPP. Half (~750,000) are transferred to the acclimation site in mid-February and released in mid-March and the other half are transferred in Mid-March and released in mid-April. Approximately 1.08 million fall Chinook salmon are released in the Umatilla River annually, of which 600,000 are subyearlings and 480,000 are yearlings. Half of the subyearlings (~300,000) are transferred to the Thornhollow acclimation site (RM 73.5) in early May and released in late May at 50 FPP, whereas the other half are direct stream released at Umatilla RM 49 in late May at 35 FPP. All yearling fall Chinook salmon are acclimated and released from the Thornhollow acclimation facility at 10 FPP. One half (240,000) are transferred in mid-February and released in mid-March, while the second half is transferred in mid-March and released mid-April.

Program Performance

The stray rate for hatchery summer steelhead has not been estimated. The mean smolt-to-adult survival rate for brood years 1991-97 was 0.42% (small grade range: 0.03-0.21; large grade range: 0.02-1.52; Chess et al. 2003a). The annual return of summer steelhead to TMFD averaged 819 for the 1992-93 through 2003-04 run years (Table 8-63). Natural-origin summer steelhead returns for the same period averaged 1,668 annually. Harvest has not met expectations, with fewer than 100 steelhead caught annually from 1994 to 1999 (Chess et al. 2003a). However, an

estimated 114 steelhead were caught in 2000-01 and an estimated 278 were caught in 2001-02 (Chess et al. 2003b).

Potential Limiting Factors Influencing Viability
The net effect of the Umatilla hatchery program is unknown, but recent natural-origin escapements have been high (Table 8-63). Almost 30% of steelhead available to spawn naturally originates from the Umatilla Hatchery. The use of natural-origin steelhead for broodstock reduces the potential for divergence of the hatchery-origin steelhead from the natural-origin fish. Smolt releases occur during the normal migration period of natural steelhead, and it appears that most fish emigrate soon after release. However, there is evidence that some smolts residualize and remain in the Umatilla River another year. These fish may compete with naturally produced fish for habitat and prey resources.

Out-of-DPS strays pose several risks to the wild Umatilla steelhead population. A primary risk is spawner composition because out-of-DPS strays account for a mean of 4.8% of fish that return to TMFD, and because average hatchery fraction on the spawning grounds is 29.4%.

8.6.6 Walla Walla River Steelhead

There is one summer steelhead hatchery program in the Walla Walla River, operated by the Washington Department of Fish and Wildlife (Glen Mendel, WDFW, personal communication).

Lyons Ferry Hatchery
The Lyons Ferry Hatchery (LFH) segregated program involves the release of non-endemic LFH steelhead stock in the Walla Walla subbasin. Approximately 100,000 smolts are direct stream released annually in the lower Walla Walla River just downstream of the Mill Creek confluence. Smolts released into the Walla Walla have been targeted at 4.5 fish per pound to reduce residualism, insure rapid emigration, reduce interactions between wild and hatchery steelhead, and increase survival (WDFW 2005).

The LFH stock program utilizes a non-endemic steelhead hatchery stock originally developed from Wells Hatchery (Wells Stock) on the upper Columbia River. Other steelhead stocks were also used in the past to fulfill production needs (Wallowa, Pahsimeroi, Oxbow, and Ringold stocks). Hatchery origin adults (mainly Wells and Wallowa stocks) were later trapped on site at LFH to build LFH stock summer steelhead.

Broodstock Source, Collection and Spawning
Broodstock collection, spawning, incubation, and juvenile rearing for the program are conducted at LFH. Well water (52^{o}F) is the source for all facets of the hatchery production. The hatchery is operated in compliance with all applicable fish health guidelines and facility operation standards and protocols. Fish collected for broodstock are taken throughout the return or spawning period in proportions approximating the timing and age distribution of the population from which broodstock is taken. Annual broodstock collections goals for all LFH stock summer steelhead production programs are 360 adult hatchery returns. Additional fish may be collected to account for pre-spawning loss and incidence of IHNV in egg lots that are destroyed. Adults are spawned two males per female. Eggs are incubated without temperature regulation. Average eggs/female

is about 4,750 eggs. Fry are ponded in indoor rearing tanks and then moved to standard outdoor raceways.

Survival and Distribution

Survival data collected to date indicate 89% survival from green egg to fry, and 68% survival from fry to smolt. Currently, about 100,000 smolts of the 345,000 total LFH Stock fish produced annually are released into the lower Walla Walla River from LFH. Releases were greater in the past (Table 8-67), but have been reduced because of ESA concerns. Currently, smolts are direct stream released at a size of 4-5 fish/lb at RM 35 between April 15 and 25.

Table 8-67. Release of LFH, Wallowa, Wells and Ringold stock steelhead smolts into the Walla Walla River, 1983-2005 release years.

Release Year	Stock	River Mile	Number of smolts
1983	Wells	28	91,260
1984	Wells	35	133,235
1985	Wells	35,40	115,200
1986	Wells	30,32,35	138,845
1987	Wells, LFH	30,32,35	124,973
1988	LFH	22,24,25,27	181,166
1989	LFH,	22,24,25,27	106,140
1990	Wallowa	22,24,25,27	130,217
1991	Ringold	23,25,26,27	198,749
1992	LFH	NA	75,210
1993	LFH	35,36	83,240
1994	LFH	23,24,25,27,30,34,	159,905
1995	LFH	35	158,875
1996	LFH	30,34,35,36	170,000
1997	LFH	30,35	170,980
1998	LFH	30,35	165,855
1999	LFH	30,35	176,000
2000	LFH	35	165,500
2001	LFH	35	103,980
2002	LFH	35	99,859
2003	LFH	35	102,975
2004	LFH	35	80,143
2005	LFH	35	10,4027
		35	

The Walla Walla watershed above Nursery Bridge Dam (NBD) has been designated a wild, endemic steelhead production area. Until 1999, stray hatchery adult steelhead were trapped and removed at NBD, preventing them from entering the natural production area and spawning with wild fish. This trapping was discontinued after 1999.

The termination of trapping at NBD causes a potential threat to the diversity of the endemic steelhead population. For all brood years on record (1993-2005) the proportion of hatchery fish passing NBD and allowed to escape with natural-origin fish to the spawning grounds has remained below 5% (Table 8-68). Nevertheless, the proportion of hatchery adults escaping above NBD has been increasing since adult trapping and removal of strays ceased in 1999. Further increases in the future will increase the risk for the natural steelhead population. There is considerable evidence of genetic introgression of LFH stock into the Walla Walla natural population (Narum et al. 2004). In addition, results of telemetry studies conducted by CTUIR

demonstrated spatial and temporal overlap in LFH and natural-origin fish. Carmichael (2006) concluded that the Walla Walla steelhead population was at moderate risk for the spawner composition viability metric. However, since out-of-DPS strays are no longer removed at NBD this risk level will rise to high in the future. Overall we consider the out-of-DPS spawners to be a key threat to the Walla Walla population.

Table 8-68. Estimated numbers of adult hatchery- and natural-origin summer steelhead passing upstream of Nursery Bridge Dam from brood years 1993-2005.

Brood Year	Hatchery Steelhead	Natural Steelhead	Percent Hatchery
1993	4	1695	0.2%
1994	2	1113	0.2%
1995	10	894	1.1%
1996	15	745	2.0%
1997	10	607	1.6%
1998	6	786	0.8%
1999	2	580	0.3%
2000	27	1069	2.5%
2001	75	1548	4.6%
2002	89	2417	3.6%
2003	46	1252	3.5%
2004	NA	NA	NA
2005	15	374	3.9%
Mean	25	1,090	2.2%

In 2001, WDFW reduced the number of non-endemic smolts released into the lower Walla Walla River to reduce genetic risks to the endemic steelhead population. The reduction was justified because the adult returns were exceeding compensation goals set by the Lower Snake River Compensation Program (Glen Mendel, WDFW, personal communication). Releases in the lower Walla Walla River were reduced from approximately 170,000 smolts annually to 100,000 smolts annually in 2001. It is unknown at this time whether these reduced stocking rates will reduce genetic risks to endemic steelhead in the Walla Walla River.

WDFW is currently developing an endemic steelhead program for the Touchet River population. The Touchet is a tributary to the Walla Walla River located entirely in Washington State. The success of this program will determine whether the Lyons Ferry Hatchery stock used in the Walla Walla and Touchet rivers will continue to be propagated. Evaluation results, available in 1-2 years, will also be used to determine whether to expand the endemic program (Glen Mendel, WDFW, personal communication). If the Touchet River endemic program is successful, it is possible that the endemic stock could be used to produce smolts for release in the lower Walla Walla River.

8.7 Predation and Competition

Oregon Mid-C steelhead are also affected by threats from predation and competition.

8.7.1 Predation by Pinnipeds, Birds and Piscivorous Fish

Predation by pinnipeds, birds, and piscivorous fish in the mainstem Columbia River has become a contributing factor affecting the viability of the Mid-Columbia River steelhead DPS. Anthropogenic changes in the Columbia River have altered the relationships between salmonids and other fish, bird, and pinniped species. Some species' abundance levels have increased dramatically, particularly in localized areas, with associated changes in predation of steelhead juveniles and adults (LCREP 2006).

Predation by Pinnipeds
The abundance of native pinnipeds has steadily increased since passage of the Marine Mammal Protection Act (MMPA) in 1972. Pacific harbor seals, Steller sea lions, and California sea lions all prey on salmon and steelhead in the lower Columbia River (NPCC 2004). Before 1980, few California sea lions were observed in the Columbia River. However, in recent years, more and more sea lions have been traveling as far upstream as Bonneville Dam to prey on returning salmon and steelhead congregating below the dam. The fish often spend several days in the river below the dam before climbing the fish ladders. The minimum daily occurrence of pinnipeds at Bonneville Dam increased from 14 animals in 2002 to 54 in 2007. Some marked individuals have been repeatedly observed at Bonneville since 2002. Estimates of spring-run adult salmonid mortality due to sea lions at Bonneville Dam ranged from 0.4% in 2002 to 3.4% in 2006 and to 4.1% in 2007 (USACE 2007; USACE unpublished data). These estimates do not account for pinniped mortality occurring in the 145 miles of the Columbia River downstream of Bonneville Dam.

A pinniped hazing program has been implemented at Bonneville Dam since 2005, but the efforts have largely been ineffective. Recently, the states of Oregon, Washington, and Idaho have applied to NOAA Fisheries for authorization under Section 120 of the MMPA to lethally remove problem California sea lions. NOAA Fisheries Northwest Regional Office in Seattle has appointed an 18-person panel of experts to review the request.

Predation by Avian Predators
Alteration of the estuary environment has lead to a significant increase in the number of native bird species, such as Caspian terns and double-crested cormorants, in the area, with measurable impacts on stream-type salmonids (BPA, BOR, and USACE 2004). These increases in population in the Columbia River estuary are attributed to the deposition of dredge spoils that represent high-quality habitat for the birds (Bottom et al. 2005). The loss of habitat elsewhere has contributed to terns and cormorants effectively relocating to the Columbia River estuary, with the populations there now representing the largest nesting colonies in North America.

In 1997 it was estimated that avian predators consumed 10 to 30% of the total estuarine salmonid smolt production in that year (NPCC 2004). The draft 2005 season summary of Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River (Collis and Roby 2006) estimates that 3.6 million juvenile salmonids were consumed by terns in 2005. Double-crested cormorants consume a similar number of juvenile salmonids (approximately 3.6 million juveniles) from their East Sand Island nesting grounds (LCREP 2006; Collis and Roby 2006). Caspian terns on Crescent Island, an island in the mid-

Columbia that was also created by dredge spoils, consumed an estimated 679,000 juvenile salmonids during the 2001 breeding season (Antolos et al. 2005).

Predation by Piscivorous Fishes

The northern pikeminnow is a native piscivore that preys on juvenile salmon and steelhead in the Columbia River. Although northern pikeminnow have always been a significant source of mortality for juvenile salmonids in the mainstem Columbia, changes in physical habitats may have created more favorable conditions for predation (NPCC 2004). Dams can stress and disorient migrating smolts, making them vulnerable to predators. Dams may also delay migration, thereby increasing travel time and exposure to predators. Northern pikeminnow were found to be the major piscivore responsible for predation on juvenile salmonids, with mortality potentially similar to that caused by dam passage (Rieman et al.1991). Since 1990, the Northern Pikeminnow Management Program (NPMP) has implemented fisheries targeting northern pikeminnow at an exploitation rate of 10-20%. This level of exploitation is expected to reduce predation on juvenile salmonids by 25-50% (Rieman and Beamesderfer 1990).

A wide variety of fish species have been introduced into the mainstem Columbia River. Among these introduced species, walleye, smallmouth bass, and channel catfish are considered to be the most successful as predators of juvenile salmonids (Gray and Rondorf 1986; Poe et al.1991). Densities of non-indigenous predators have been found to be higher in impoundments created by mainstem dams compared to the unimpounded Columbia River below Bonneville Dam (Zimmerman and Parker 1995). Sampling suggests that smallmouth bass abundance in The Dalles and John Day reservoirs, as well as walleye abundance in parts of John Day Reservoir, has increased in recent years (Takata et al. 2007). Although non-indigenous species do not prey on juvenile salmonids to the extent that northern pikeminnow do, they can be an important predator at certain times and locations (Poe et al.1991).

8.7.2 Intra-Species Interactions

Unique to the Deschutes River Westside population is the presence of a highly abundant population of large resident rainbow trout throughout the population. Nowhere in any of the other Oregon Mid-C steelhead populations, except in the mainstem Deschutes River reaches of the Deschutes River Eastside population, are abundant large rainbow trout found. Cramer and Beamsderfer (2006) concluded that habitat conditions (perennial steady flows and cool temperatures) in many areas in the upper Deschutes subbasin favor production of resident rainbow trout over steelhead. Similar habitat conditions are also found in much of the currently available habitat of the Deschutes River Westside population.

Current abundance for steelhead in the Westside population is low relative to the quantity and quality of habitat available. With the exception of the South Fork John Day River population, the Deschutes River Westside population has the lowest current abundance of all other Oregon Mid-C steelhead populations.

Although we cannot quantify the effects of resident rainbow trout on the capacity of steelhead in the Westside population, we hypothesize that the capacity may be significantly reduced by competition with resident rainbow. This hypothesis is supported by the conclusion of Cramer

and Beamesderfer (2006) regarding steelhead production capacity in the upper Deschutes subbasin. Although there may be reduced steelhead capacity resulting from the abundance of resident rainbow trout, this should be viewed as a natural outcome. Thus, no management actions are proposed to address this potential natural interaction effect. If, in the future, additional studies confirm this reduction in capacity in waters with abundant larger rainbow trout, then the abundance criteria for the Deschutes River Westside steelhead should be reevaluated.

8.8 Climate Change

This section describes the potential environment changes that will accompany climate change in the future and some likely life stage specific responses for Oregon's Mid-C steelhead. In addition, we have developed a potential climate change vulnerability risk index based on projected future stream temperatures, projected future springtime water availability, and historical variation in precipitation.

8.8.1 Steelhead Habitat Impacts

Climate change will alter environmental conditions across the entire life cycle for all life stages of Oregon's Mid-Columbia River steelhead. There remains considerable uncertainty regarding the magnitude of loss and degradation of salmonid habitat in the Columbia Basin that will result from climate change. The magnitude of environmental change will vary considerable across ecoregions and thus will have different impacts on viability of steelhead populations within the Mid-C DPS. In general, habitats at lower elevations east of the Cascade Mountains in the southern portion of the Columbia River basin will experience the greatest level of change (ISAB 2007a).

Many of the environmental attributes that will be influenced by climate change (temperature and hydrograph) are those that have already been influenced significantly by past land use and are currently considered key limiting factors. The degree to which climate change will impact a given population is partially dependent on the degree to which natural processes have already been altered. A number of reviews have recently been completed that characterize potential climate change impacts in the Pacific Northwest (O'Neal 2002; Mote et al. 2003; ISAB 2007a; Michael and O'Brien 2008). The environmental changes most often described as significant threats to salmonid viability include:

- Increased air and stream temperatures
- Reduced snow pack and a shift in precipitation from snow to rain
- Altered hydrographs with earlier and higher peak flows, and lower summer-fall flows
- More frequent extreme storm events
- Increased periods of drought
- Changing ocean temperatures and current patterns
- More frequent and severe fire events

8.8.2 Potential Life Stage Specific Impacts

The ISAB (2007) generally characterized potential impacts of climate change to salmonids in the Columbia River basin. Expanding on their conclusions with a specific focus on Oregon's Mid-Columbia River steelhead, we developed the following summary of potential life stage specific impacts of climate change. Again, we emphasize that the life stage specific impacts will vary considerably between populations based on many factors, and our summary attempts to capture the range of potential impacts across all populations.

Egg incubation: The potential for increased mortality exists due to increased flood events in early spring resulting in greater redd scouring and dewatering of redds due to low spring flows (Jager et al. 1997). Increased temperatures will result in accelerated embryo development and earlier fry emergence.

Fry emergence and colonization: Warmer spring temperatures will likely result in earlier fry emergence. Fry emergence timing is critical for successful colonization, thus altered emergence timing may reduce success in colonizing quality habitat and increase mortality.

Summer rearing: Most Mid-C steelhead spend a minimum of two summers srearing prior to smolt seasonal migration. Reduced summer flows and increased temperatures will impact both the quality and quantity of summer rearing habitat. Summer temperatures currently limit habitat quality and quantity in most Oregon Mid-C populations. Lower flows and warmer temperatures have the potential to influence steelhead in many ways. The potential effects include the following:

- Reduced rearing capacity due to loss of habitat that reaches lethal temperatures
- Reduced growth rates due to metabolic stress of high temperatures
- Increased growth rates in some locations that are currently below growth optimum temperatures
- Reduced ability to compete with non-native and native competitors due to elevated temperatures
- Increased predation mortality resulting from more active, abundant, and effective predators at high temperatures

Overwinter Rearing
Environmental changes have the potential to influence growth and survival including:

- Reduced growth rates resulting from higher metabolic demands and low available food resources
- Increased growth rates resulting from increased temperatures
- Increased overwinter mortality resulting from more frequent and intense winter flood events
- Reduced or improved overwinter survival resulting from changes in body size at the onset of winter

Smolt Migration
Environmental changes have the potential to influence migration timing and survival including:

- Alteration of smolt seaward migration timing as a result of hydrographic changes, prior life stage growth patterns, and size-at-age
- Alteration of the proportion of steelhead offspring that express anadromous and resident life history strategies as a result of changes in prior life stage growth rates and size-at-age
- Increased smolt mortality in tributary and mainstem migratory corridor due to elevated temperatures and increased predation
- Increased smolt mortality resulting from prolonged migration timing resulting from reduced flows

Smolt to Adult Ocean Rearing
Environmental changes have the potential to influence survival, growth, and age-at-maturation including:

- Increased mortality at time of ocean entrance due to mismatch in smolt physiology and ocean entrance timing
- Reduced early ocean survival due to changes in temperature, plume dynamics, and predator-prey relationships
- Altered ocean growth patterns due to elevated temperatures and altered current patterns resulting in reduced survival and changes in adult age at return

Adult Migration and Holding
Environmental changes have the potential to influence migration timing, survival, and straying including:

- Reduced migration success and increased mortality due to increased mainstem temperatures during the summer migration period. Increased temperatures can influence migration success and survival in a variety of ways including increased energetic demands, delayed passage, and direct mortality due to lethal temperature encounters
- Potential for increased straying, for some populations, into summer coldwater refugia like the Deschutes River
- Increased pre-spawn mortality due to high late summer and fall temperatures in adult holding habitat

Adult Spawning
Environmental changes have the potential to influence spawn timing and spawner distribution including:

- Shifts in adult spawn timing resulting from increased temperature and associated changes in sexual maturation rates during adult migration and holding periods (some Mid-C adult steelhead spend up to 11 months in freshwater prior to spawning)
- Shifts in adult spawner distribution due to flow and temperature changes in tributary spawning areas.

8.8.3 Potential Vulnerability Risk to Climate Change

Introduction

There is a considerable amount of new information available regarding the potential impacts of climate change on air temperature, precipitation, and rain/snowfall patterns. Although some work is underway to assess the impacts of environmental change on salmon in the Pacific Northwest, there is no spatially explicit information available for Oregon's Mid-C steelhead populations that links climate change to potential vulnerability.

We have taken the first step in linking climate change to potential vulnerability risk by developing an integrated risk analysis. One key objective of this effort is to produce maps that will serve as the basis for comparing the high priority tributary habitat actions and targeted limiting factors with geographic areas that are most vulnerable to climate change impacts. We want to emphasize that this effort is only a first step and that this should serve as a stepping stone for others to build from and improve on.

As discussed earlier, climate change will pose significant challenges to steelhead ecology throughout the entire life cycle. The magnitude of environmental change will vary considerably from one geographic area to another, even within the boundaries of an individual population. Ideally, we would like to assess the potential effects of climate change on abundance, productivity, spatial structure, and diversity of all Oregon Mid-C populations and determine the effectiveness of our management strategies in addressing climate impacts. However, the state of knowledge is not yet advanced to the point to allow this level of quantitative assessment.

To characterize spatially explicit, potential vulnerability risk we utilized available environmental information to develop three risk metrics and a combined overall risk metric that integrates the three individual metrics. We chose key environmental parameters that should change significantly under all climate change scenarios and that should provide adaptive challenges to multiple life stages of Mid-C steelhead. We selected changes in springtime available water (Graves 2008) to index potential future risk for spawning and changes in peak summer temperature (Cooney and Holzer, *in prep*) to index potential future risk for summer rearing capacity and growth, incubation, and emergence/colonization. We also utilized past variation in precipitation (Brown 2009) as an index of adaptive capacity.

Approach

Springtime Water Availability Change (SWAC)

Graves (2008) compiled contemporary climate conditions (1971-2000) from PRISM data (Daly et al. 1994) in a GIS format for Columbia Basin watersheds. He then conducted an analysis to assess monthly water balances from precipitation and snowmelt for three future climate timeframes (2020s, 2040s, and 2080s) using future projections of monthly temperatures and precipitation changes generated by the University of Washington Climate Impact Group (UWCIG 2007). This UWCIG (2007) data included monthly expected change in temperature and precipitation from the baseline period including 2010-2029 (2020s), 2030-2059 (2040s) and 2070-2099 (2080s). These projections of change were applied to the spatial grid of contemporary climate, producing a scalable result. Graves (2008) assessed changes in water availability for seven subbasins that are of importance to Columbia River Basin tribes.

We conducted our analyses in a five step sequence:

1. We obtained percent change in water availability from contemporary climate conditions (1971-2000) to the 2040s future climate scenario (Graves 2008).

2. We aggregated the data for each 6th field hydrologic unit (HUC6) for all Mid-C populations.

3. We calculated the percent springtime water availability change (SWAC) for each month and each HUC6. We selected the months of March, April, and May for our analyses because these months represent the period of time for spawning, incubation, fry emergence and fry colonization for most Oregon Mid-C steelhead. Therefore, hydrograph changes during this critical time period will pose significant adaptive challenges to multiple life stages.

We calculated the mean percent directionless change in springtime water availability for each HUC6 as:

$$\overline{SWAC} = \frac{|SWAC_1| + |SWAC_2| + |SWAC_3|}{N_{SWAC}}$$

where

$SWAC_1$ = March absolute value of percent change in water availability

$SWAC_2$ = April absolute value of percent change in water availability

$SWAC_3$ = May absolute value of percent change in water availability

N_{SWAC} = number of months

4. We developed risk rating criteria to categorize values into four risk levels. Criteria were based on expert opinion, manually selected categories:

Very Low Risk: $\overline{SWAC} = 1.2\%\text{-}5.0\%$
Low Risk: $\overline{SWAC} = 5.1\%\text{-}15.0\%$
Moderate Risk: $\overline{SWAC} = 15.1\%\text{-}35.0\%$
High Risk: $\overline{SWAC} = 35.1\%\text{-}203.1\%$

5. We mapped the $\overline{SWAC}$ and risk rating for each HUC6 for all populations. These results were used in the development of the integrated risk assessment.

Summer Temperature Change (STC)

Interior Columbia basin naturally produced steelhead populations rely on tributary habitats for juvenile rearing. Interior steelhead typically emerge from spawning gravels in the early summer of their natal year, spending two or more summer growth seasons in freshwater prior to

emigrating to the ocean. Smolt outmigration sampling indicates that emigration may be triggered by reaching a size threshold (e.g., Mullan et al. 1992). As with other salmonids, stream temperatures are extremely influential on juvenile growth and mortality rates (McCullough 1999).

Climate modeling projections for the Interior Columbia indicate a warming trend in air temperatures over the next 20 to 80 years (e.g., Mote and Salathe 2009). Mantua et al. (2009) developed statistical models relating patterns in available historical stream temperature records to associated air temperature estimates from throughout Washington State. The stream sites used in that analysis were largely associated with major mainstems or lower sections of river systems, very few of the sample series in their study were from upper tributary habitats used by juvenile steelhead. Cooney and Holzer (*in prep*) used recent historical stream temperature series from upper tributary habitats, exhibiting the physical characteristics associated with juvenile steelhead rearing, to model the potential impacts of increased temperatures on juvenile steelhead growth potential. This analysis had two major objectives: to highlight high intrinsic potential steelhead production areas across populations within the Columbia River basin that are particularly vulnerable to projected temperature increases and to identify representative drainages in which to carry out more detailed temperature assessments that would include groundwater interactions, etc.

Recent historical stream temperature data: Stream temperature data sets were collected from various agencies, including federal (USGS, NOAA), state (Oregon Department of Environmental Quality, Washington State Department of Ecology), and tribal (Nez Perce) sources. The candidate data sets were limited to those that: 1) included at least two summers after 2000, and 2) were located within Interior Columbia basin stream reaches identified as historic or current natural steelhead spawning/rearing areas. In a few cases, locations on streams blocked to anadromous migration were included in order to incorporate data series from underrepresented ecotypes. The Yakima River mainstem sites were excluded due to the influence of the highly modified flow regimes in that system. In addition, locations elsewhere throughout the Interior Columbia basin that are located directly downstream from reservoirs were excluded. Cooney and Holzer (*in prep*) also discarded temperature series in very small tributaries directly associated with springs. After screening, a total of 167 sites were available for the analysis.

Stream temperature models: Stream temperatures in a given tributary reach can be influenced by a number of factors in addition to local air temperatures (e.g., Isaak and Hurbert 2001). Reach specific factors that could influence stream temperatures include air temperature, topography, flow, geology (e.g., potential for groundwater influence), and shading. Stream temperatures in a tributary reach can also be influenced by upstream conditions such as basin area, mean precipitation, ice or snow contribution (such as from glaciers) and geology. A set of candidate variables representing these potential factors was selected from available Interior Columbia basin GIS data sets.

A forward stepwise multiple regression analysis (Statgraphics REGRESS routine) was used to generate statistical models of mean summer stream temperatures (defined as the maximum two week average stream temperature during July or August). A cross-validation approach was used for the analysis, each of the 167 site-series was randomly assigned to one of three groups. The

stepwise multiple regression analysis was repeated three times, leaving out one of the random groups for each repeat. Residuals were calculated for the out-of-sample set for each of the three runs and tabulated. Three variables were identified among the three runs as having the most significant influence: mean maximum air temperature, elevation range (ln) and percent forest cover. A fourth variable, basin alluvial geology, was included in the analyses for two of the three subsets. Given the high degree of consistency among results from the subset analyses, the data sets were combined in an aggregate analysis.

Projected stream temperatures: The resulting aggregated stream temperature model was applied to estimate two-week mean average stream temperatures for current steelhead rearing habitats in accessible stream reaches and potential habitat within extinct population reaches. Estimates were expressed at the reach level for rearing habitats associated with each Interior Columbia steelhead population. The current distribution of steelhead production within stream networks was adapted from ICTRT data and generally reflects the distribution extent developed by state agencies (WDFW, ODFW, and IDFG). Historically occupied areas that are targeted for reintroductions were incorporated using an intrinsic potential habitat analysis (ICTRT 2007) as a proxy for current distribution. Temperature estimates were calculated for current conditions as well as for climate change projections. The potential increases in stream temperatures corresponding to future climate scenarios were generated by increasing the estimated current air temperature input values at the reach level by the average incremental change projected by the climate models (1.1, 1.3 and 3.1 °C by 2020, 2040 and 2080 after Mantua et al. 2009). The resulting point estimates of mean temperature by stream reach were summarized by HUC6 subbasins. Aggregate values were then assigned to potential growth categories. The growth categories were assigned based on information summarized in McCullough (1999) and are presented below:

Stream Temperature	Growth Impact Assumption
<4.5 °C	Zero Growth
4.5 to 10 °C	Cold Growth
10 to 15 °C	Optimum Growth
15 to 19 °C	Warm Growth
19 to 20 °C	Zero Growth
> 20 °C	Negative Growth/Lethality

We mapped the temperatures and growth categories for current conditions and a 2080 temperature scenario.

Risk assessment: The statistical models used to estimate stream temperatures had a relatively high degree of uncertainty. An estimate of the relative uncertainty in predicting stream temperatures based on a residuals analysis was directly incorporated in calculating a relative risk index at the reach level summarized by HUC6. The risk index was expressed relative to the

lower threshold of zero growth temperature zone (19 °C). Using either the aggregate or composite model, approximately 80% of observed temperature values fell above the model predicted value +2 °C. If the point estimate of stream temperature for a HUC6 was between 19 and 21 °C the risk was classified as High. If the point estimate exceeded the 19 °C threshold by 2 °C or more, the risk rating was set at Very High. If the point estimate was more than 2 °C below the threshold (<17 °C), the HUC6 was rated at Low risk. Relative risk levels were assigned based on the following thresholds:

Predicted Temperature	Assigned Risk
< 17 °C	Low
17 to 19 °C	Moderate
19 to 21 °C	High
> 21 °C	Very High

The relative risk levels for the 2080 scenario were mapped and incorporated into the integrated risk analyses.

Historical Precipitation Variation (HPV)

We used historical precipitation variation as a metric to index adaptive capacity. As discussed earlier adult spawn timing, egg incubation, and fry emergence are key Mid-C steelhead life stages that are likely to be impacted by climate change, specifically hydrograph and temperature changes.

A variety of salmon life history traits have been shown to vary with environment characteristics including flow, elevation, and temperature (Waples et al. 2004; Quinn 2005). Characteristic life history strategies, that are often geographically unique, represent adaptation to local environmental conditions (Lichatowich 1999). Many authors have concluded that life history strategies are an adaptive response to environmental conditions and when climate or habitat changes occur some life history strategies will perform better than others (Lichatowich 1999). McClure et al. (2008) concluded that some key adult and early life-stage traits are closely linked with environmental conditions and have moderate to high levels of heritability. Particularly relevant to Mid-C steelhead vulnerability to hydrograph and temperature changes, phenotypic traits such as adult migration timing, spawn timing, developmental rate, and emergence timing are known to be heritable and vary between populations.

Life history diversity and degree of local adaptation are key elements influencing population capacity to deal with variable and changing environments. The ability of populations to adapt to changing environments depends, in part, on the rate and magnitude of environmental change as well as the inherent life history variation. Those populations that persist in highly variable environments and that exhibit diverse life history patterns will likely have greater capacity to

adapt to changing environments. Brown (2009) hypothesized that the capacity of basins to adapt to water availability changes will likely be dependent on the level of historic precipitation. We hypothesize that populations which persist in areas with highly variable precipitation patterns will have greater resilience to future climate change than populations which reside in low precipation variability areas.

To link environmental variation to adaptive capacity risk, we conducted the HPV analyses in a four step sequence:

1. We obtained precipitation coefficient of variation data from Brown (2009) with the original data source of PRISM.

2. We aggregated the data for each HUC6 for all Mid-C steelhead populations.

3. We developed risk rating criteria to categorize values into four risk levels. Categories were based on natural break (Jenks 1967) methodology:

Very low risk:	CV = 0.688 – 0.865
Low risk:	CV = 0.596 – 0.687
Moderate risk:	CV = 0.513 – 0.595
High risk:	CV = 0.413 – 0.512

4. We mapped HPV and risk ratings for each HUC6 for all populations. We then used the HPV results in the integrated risk assessment.

Integrated Potential Vulnerability Risk

We combined the three individual risk metrics to develop an integrated potential vulnerability risk index. The integrated risk index was developed to identify the geographic areas where climate change is projected to influence multiple environmental factors and life stages. We weighted the influence of STC risk greater than $\overline{SWAC}$ risk, and $\overline{SWAC}$ risk greater than HPV risk. We placed the greatest weight on STC because of the potential impacts to capacity, survival, and life history that are associated with the magnitude of temperature changes that are projected to occur.

We developed rating criteria to categorize risk into four levels. Table 8-69 shows the combinations of $\overline{SWAC}$, STC and HPV which were designated as very low, low, moderate and high risk.

Very low risk: assigned when the metric combinations were low risk and very low risk.

Low risk: assigned when the metric combinations included one metric at moderate risk with two metrics at low or very low risk, or, all three metrics with low risk.

High risk: assigned when STC was very high risk regardless of the other metric ratings, when there were two high risks with any other risk rating, and if $\overline{SWAC}$ or STC were high and the other two metrics were moderate.

Moderate risk: assigned to all other risk combinations.

We mapped the integrated risk index for each currently occupied HUC6 for all populations and HUC6s in the Deschutes Basin where steelhead reintroductions are planned.

Table 8-69. Criteria for considering springtime water availability change ($\overline{SWAC}$), summer temperature change (STC), and historical precipitation variation (HPV) climate change risk metrics into an integrated potential climate change vulnerability index. The order of individual metric risk ratings is $\overline{SWAC}$, STC, HPV. (VH=Very High; H=High, M=Moderate, L=Low, VL=Very Low)

Integrated Risk Category			
High Risk	Moderate Risk	Low Risk	Very Low Risk
H VH H	M H L	L M L	L L VL
H VH M	M H VL	L M VL	VL L L
H VH L	L H M	VL M L	VL L VL
H VH VL	L H L	VL M VL	
M VH H	L H VL	M L L	
M VH M	VL H M	M L VL	
M VH L	VL H L	L L M	
M VH VL	VL H VL	L L L	
L VH H	H M L	VL L H	
L VH M	H M VL	VL L M	
L VH L	M M H		
L VH VL	M M M		
VL VH H	M M L		
VL VH M	M M VL		
VL VH L	L M H		
VL VH VL	L M M		
H H H	VL M H		
H H M	VL M M		
H H L	H L M		
H H VL	H L L		
M H H	H L VL		
M H M	M L H		
L H H	M L M		
VL H H	L L H		
H M H			
H M M			
H L H			

Results and Discussion

Springtime Water Availability Change

The percent change in springtime water availability and the associated risk levels are shown for each HUC6 in Figure 8-20. We observed a similar pattern in springtime water availability as described in Graves (2008) and Mantua et al. (2009). Mantua et al. (2009) concluded that many of the Washington State Mid-Columbia River steelhead basins will transition from rain and snow basins to rainfall dominant basins resulting in significant hydrograph shifts. In our analysis, moderate to higher elevation areas showed the greatest $\overline{SWAC}$, and thus the highest risk levels. There were only a few populations with substantial areas that were rated as high risk, including the North Fork, Middle Fork, and Upper Mainstem John Day populations. The geographic areas with the highest risk levels were those areas with significant at-risk snow (Nolin and Daly 2006; Brown 2009) that are projected to shift from snow-dominated to rain-dominated precipitation patterns by mid-century (Graves 2008). Much of the currently occupied spawning habitat within all populations, except the Deschutes River Eastside and Lower John Day River, was classified at moderate risk.

The water availability at HUC6 scale serves as a reasonable index of potential hydrograph changes for headwater and lower order streams. However, flow in larger mainstem, higher order streams is not influenced significantly by local area water availability, rather by upstream tributary flow inputs. Therefore, the $\overline{SWAC}$ analysis does not effectively index potential hydrograph changes for mainstem higher order stream reaches. The effect of this bias on our analysis is somewhat minimized because steelhead spawning distribution is concentrated in lower order tributary streams. The development of hydrologic models (see Mantua et al. 2009) to characterize future hydrograph changes would significantly improve the ability to characterize geographic specific risk to Mid-C steelhead in Oregon. In addition, inclusion of ground water inputs as well as water withdrawals would increase the value and applicability of the analysis.

Summer Temperature Change

Modeled, mean stream temperatures and the associated steelhead growth zones for current conditions and the 2080 climate scenarios are shown in Figures 8-21 and 8-22 respectively (Cooney and Holzer, in prep). Significant proportions of the Deschutes River Eastside, Lower Mainstem John Day River, Umatilla River, and Walla Walla River populations currently exhibit mean summer temperatures residing in the zero net growth and negative growth zones (Figure 8-21). Many of the streams and rivers within the Mid-Columbia Oregon population boundaries exhibited mean summer temperatures in the negative growth zone in the 2080 climate scenario (Figure 8-22). A majority of the streams and rivers within the boundaries of the Deschutes River Eastside, Lower Mainstem John Day River, Umatilla River, and Walla Walla River populations show predicted mean summer temperatures exceeding 20 °C in the 2080 climate scenario (Figure 8-22).

Maximum mean summer stream temperature risk levels are shown in Figure 8-23. All populations showed areas with Very High and/or High risk. Populations that showed the greatest vulnerability with large proportions of the streams and rivers in Very High and High risk included the Deschutes River Eastside, Lower Mainstem John Day River, Umatilla River and Walla Walla River. All populations exhibited Low and Moderate risk categories at the higher elevation headwater reaches (Figure 8-23).

Historical Precipitation Variation

The historical coefficient of variation and associated risk levels are presented in Figure 8-24. A pattern emerged that showed low precipitation variation and high risk ratings in currently occupied areas within populations in the eastside of the DPS (SF, Upper Mainstem, MF, NF John Day River, Umatilla River, and Walla Walla River) whose headwaters originate in the Blue Mountains. In contrast, currently occupied areas within populations in the westside of the DPS (Fifteenmile Creek and Deschutes River Westside) whose headwaters originate from the eastslope of the Cascades Mountains showed moderate to high precipitation variation and moderate to low risk ratings (Figure 8-24).

Integrated Potential Vulnerability Risk

Extensive geographic areas within all populations, except Fifteenmile Creek and Deschutes River Eastside, exhibit high vulnerability risk (Figure 8-25). In addition, all populations have a substantial proportion of the geographic area rated at moderate risk.

Two patterns emerged that are characteristic of the areas rated at high risk. High risk levels for higher elevation areas within the John Day River populations were attributable to the combination of high risk for $\overline{SWAC}$ and HPV. In contrast, the high risk ratings for lower elevation areas in many of the populations, particularly evident in the Lower Mainstem John Day, Umatilla and Walla Walla populations, resulted primarily from the STC risk.

Results that are of particular concern for Oregon's Mid-C steelhead populations include:

1. The very small number of HUC6s that were at low or very low risk.

2. Many populations, including the South Fork John Day, Upper Mainstem John Day, Middle Fork John Day, North Fork John Day, Umatilla and Walla Walla, have the entire geographic area within the population boundaries rated at moderate or high risk.

3. The combination of environmental characteristics that are projected to change under future climate scenarios will threaten capacity, productivity, diversity and spatial distribution from both lower elevations upward and higher elevations downward. The life stages, capacity, and productivity impacts will vary depending on the specific environmental factors that are altered and the adaptive capacity.

As discussed earlier, we recognize this is a first step in development of a climate change vulnerability index for Oregon's Mid-C steelhead. Significant improvements to the approach can be made with use of hydrologic models that project reach scale flow changes, use of historical flow variation instead of precipitation variation, and incorporation of other environmental factors and life stages in the analysis. In addition, it would be beneficial to examine the relationship between current life stage specific habitat use and potential vulnerability risk for each population.

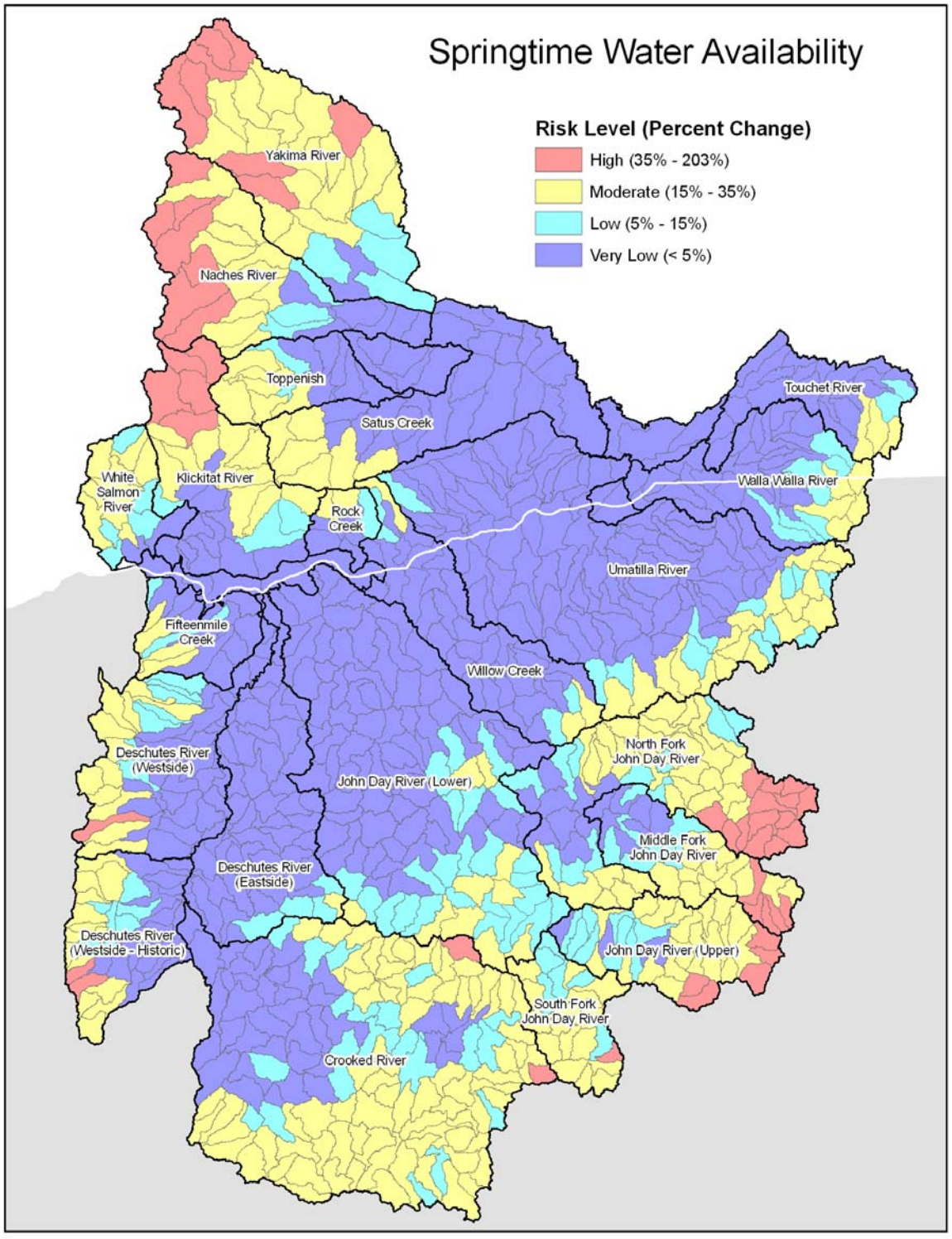


Figure 8-20. Percent change in springtime water availability (March-May) from baseline conditions (1971-2000) to future conditions (2040s) and projected future relative risk to Mid-Columbia River steelhead (6th field hydrologic units). Data sources include Graves (2008) and UWCIG (2007).

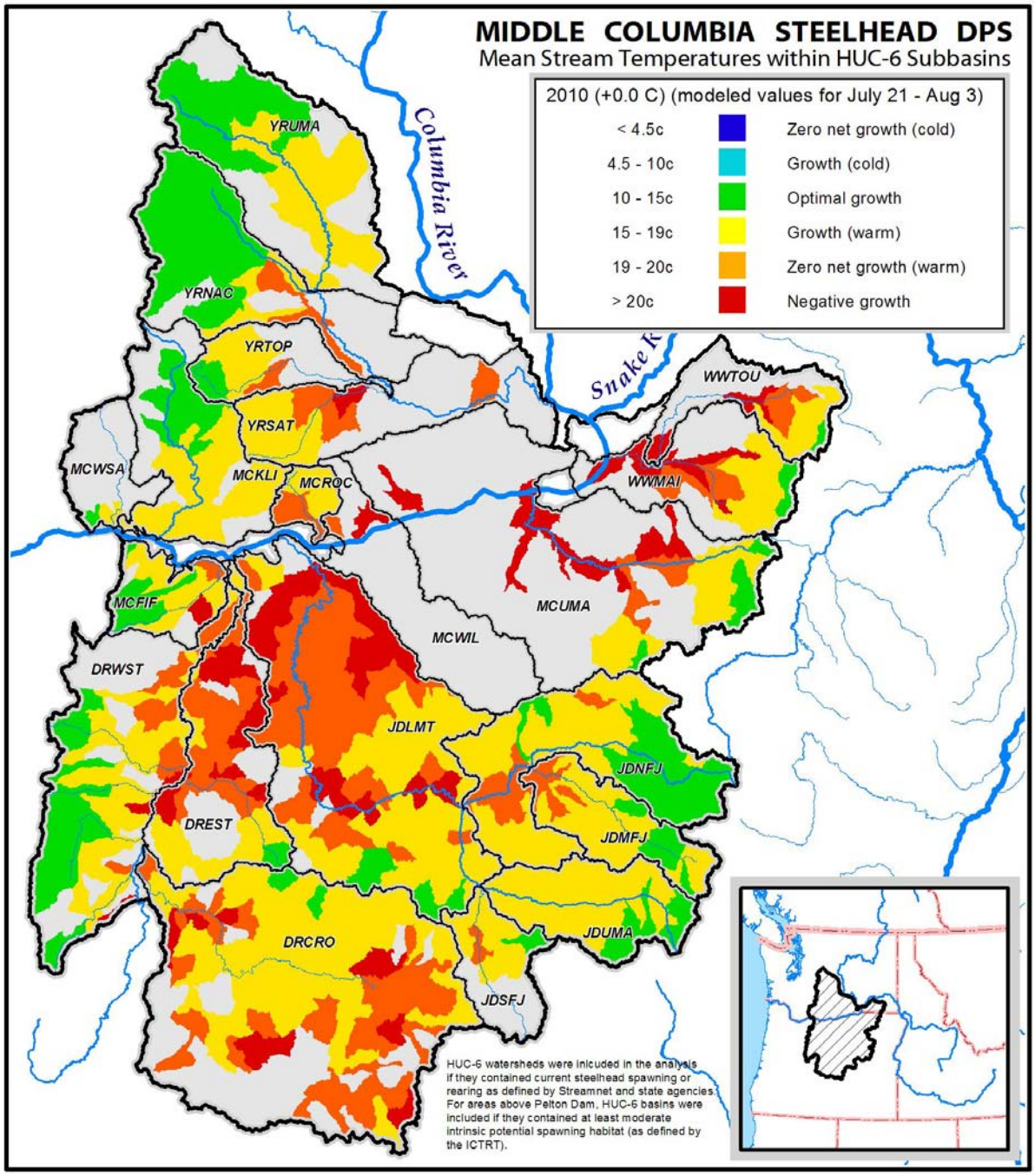


Figure 8-21. Modeled current summer (July 21-August 3) stream temperatures and growth zone characterization for Mid-Columbia River steelhead (6th field hydrologic units). From Cooney and Holzer, *in prep*. All areas shown in the Crooked River and Deschutes River Westside-Historic are currently unoccupied; however, reintroduction efforts are currently underway in some areas.

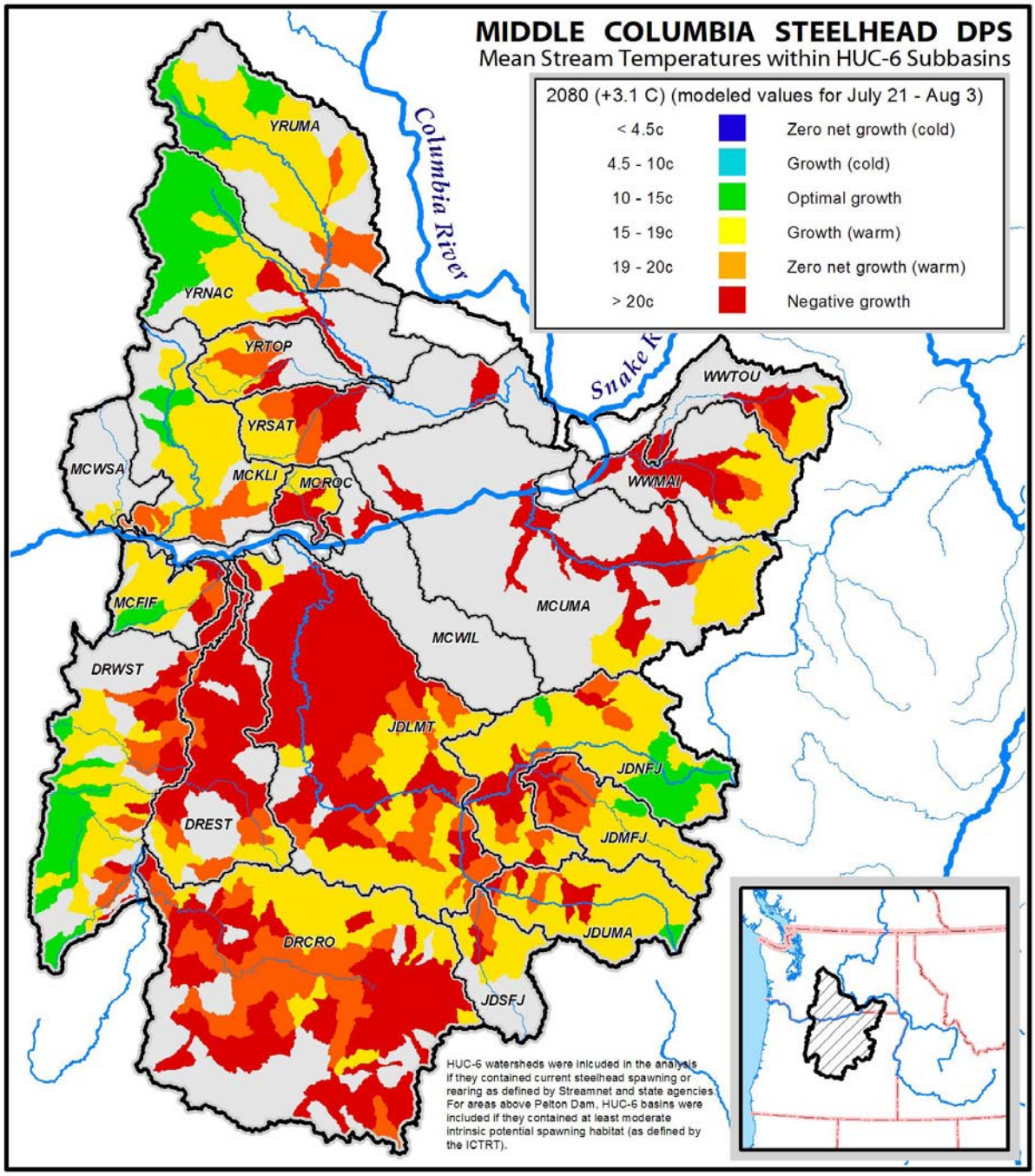


Figure 8-22. Modeled future (2080) summer (July 21-August 3) stream temperatures and growth zone characterization for Mid-Columbia River steelhead (6th field hydrologic units). From Cooney and Holzer, *in prep*. All areas shown in the Crooked River and Deschutes River Westside-Historic are currently unoccupied; however, reintroduction efforts are currently underway in some areas.

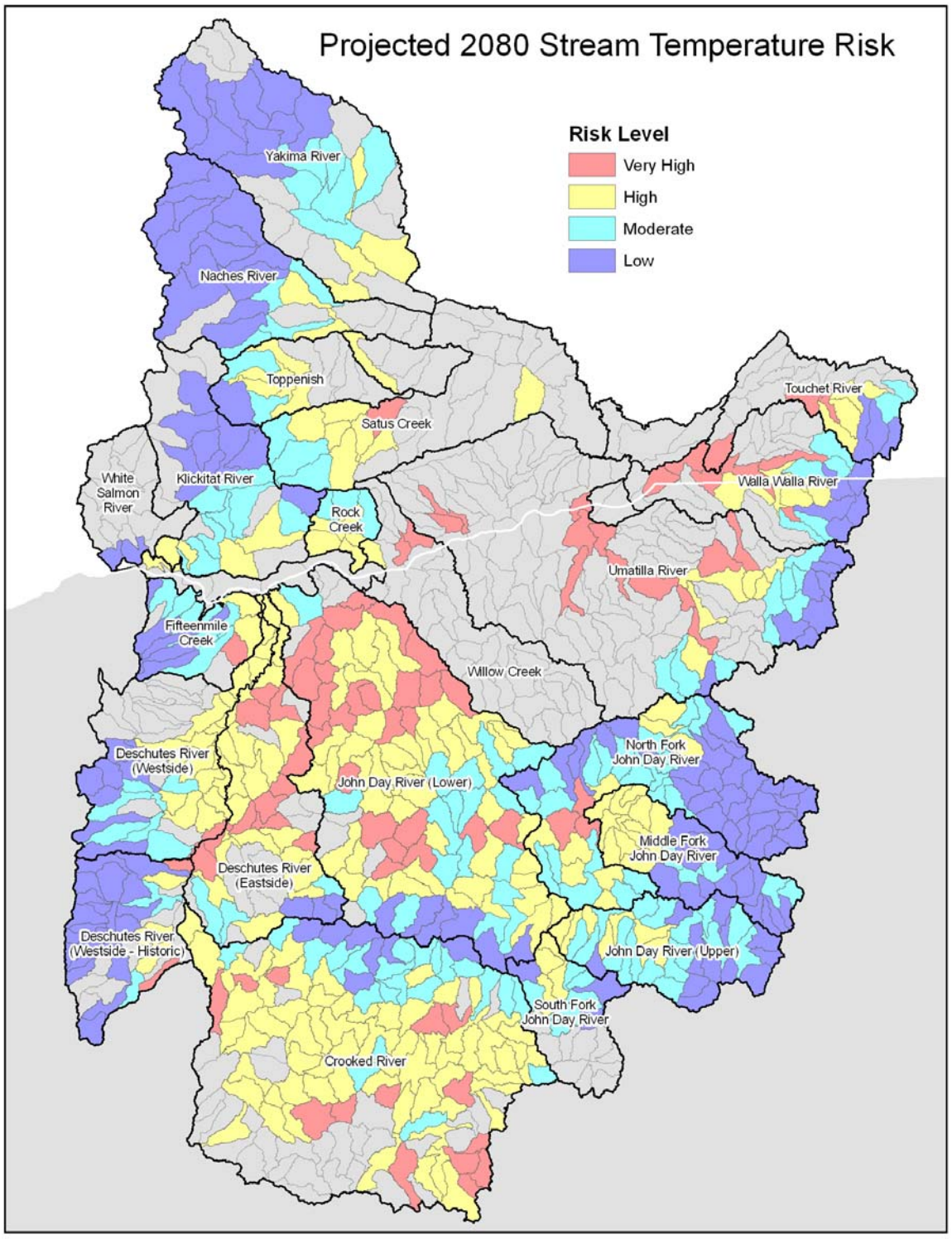


Figure 8-23. Projected future relative risk to Mid-Columbia River steelhead habitat (6th field hydrologic units) due to changes in summer (July 21-August 3) stream temperatures from current (2010) to future (2080) conditions. Data source is Cooney and Holzer, *in pre*p. All areas shown in the Crooked River and Deschutes River Westside-Historic are currently unoccupied; however, reintroduction efforts are currently underway in some areas.

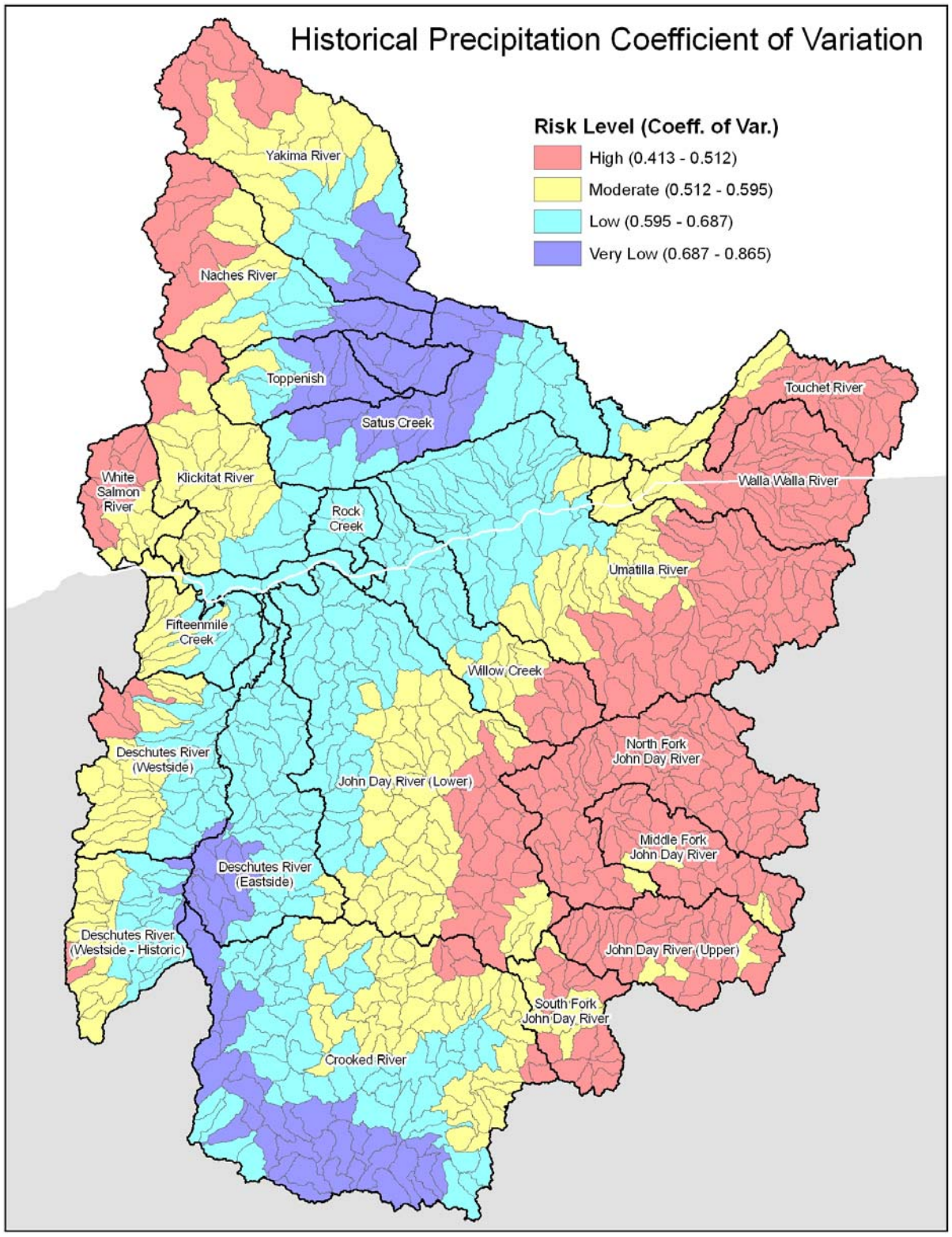


Figure 8-24. Precipitation coefficient of variation for the period (1971-2007) and relative risk for Mid-Columbia River steelhead (6th field hydrologic units). Data sources include Brown (2009) and PRISM Climate Group (2007).

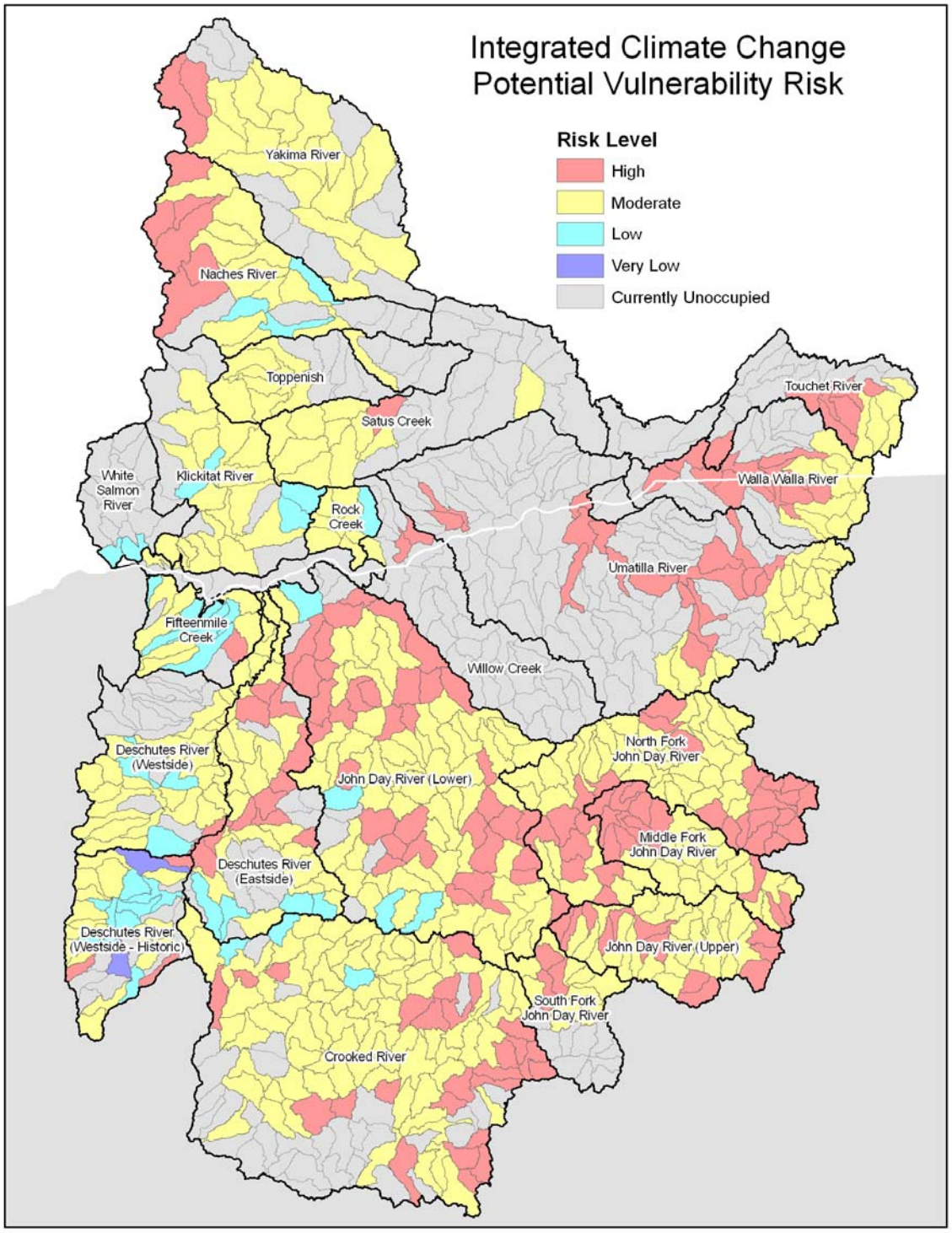


Figure 8-25. Integrated climate change potential vulnerability risk for Mid-Columbia River steelhead (6th field hydrologic units). Integrated risk index was developed from springtime water availability change risk, summer temperature change risk, and historical variation in precipitation.

Section 9 Recovery Strategies and Management Actions

This section describes strategic guidance, strategies and specific management actions proposed for achieving recovery of Oregon populations in the Mid-Columbia River steelhead DPS. The strategic guidance supplies the framework for developing strategies and prioritizing actions at all scales. The management strategies and actions provide an integrated approach to address threats across the entire life cycle. These are identified in sections 9.3 (Tributary Habitat), 9.4 (Hydrosystem), 9.5 (Estuarine and Plume Habitat), 9.6 (Harvest), 9.7 (Hatcheries) and 9.8 (Predation and Competition). Together the strategies and actions provide broad guidance for recovery efforts at the local and regional level, consistent with both regional and local visions, as well as detailed management actions.

While fundamentally intended to produce biological results, strategies and actions included in this plan also reflect economic, political, social, and cultural considerations. In particular, they are framed to regain DPS viability as well as make progress beyond delisting criteria to broad sense recovery goals. These considerations are critical to the prospects for developing and implementing an effective and equitable plan. It is expected that additional actions will be incorporated over time as part of the ongoing adaptive management process.

9.1 Strategic Guidance for Management Actions

Achieving recovery for the Mid-Columbia River steelhead DPS will depend on restoring the viability of extant populations in major population groups to levels that support the proper functioning of the DPS. This will require intensive effort by individuals at the regional, watershed and local levels. It is clear that not all of the management actions that should be implemented can be done in the near-term due to various constraints.

The purpose of this strategic framework is to provide guidance for developing and prioritizing management actions to recover Mid-C steelhead populations. Prioritized actions will lead to more timely and effective results. Our strategic vision recognizes that reversing the decline of key populations, life histories, and habitats requires use of well-formulated scientifically sound approaches. Since multiple causes are responsible for impaired population viability and disrupted ecosystem function, limiting factors and threats throughout the entire life cycle will need to be addressed in concert. Efforts must also be focused to protect and enhance populations that are critical to achieving DPS recovery.

As part of this and other planning processes, management actions and strategies were developed at multiple scales including tributaries, watersheds, and the Columbia River mainstem and estuary to achieve recovery of local populations. This strategic framework is used as strategic guidance for where, when, and how actions identified in this plan are implemented to address factors and threats limiting viability of extant and extirpated Mid-C steelhead populations.

Managing for past, current and future adverse impacts of human activities throughout the life cycle is critical to achieving recovery goals. Development and implementation of management actions that lead to recovery will require a sound understanding of conservation biology

principles and ecosystem management as well as integration of leadership, planning, funding, monitoring, policy and science such that each contributes synergistically in a timely and effective manner. The approaches to ecosystem restoration and management actions needed to achieve recovery goals will necessarily vary by ecosystem type, management objectives of the various lands and ownerships within the ecosystem, and social and economic capacity to support the effort. Actions that balance achievement of sustainable environmental, social, cultural and economic processes have the best chance of success for the long term.

The primary goals of the recovery plan are to:

1) Sustain the ecosystem processes that currently, and will in the future, support high quality habitats and their productive capacity.
2) Enhance ecosystem processes that are impaired but are currently important to productive capacity.
3) Restore habitat and ecosystem processes that were historically important but do not currently contribute to productive capacity.

We identified some key principles (adapted from Meffe and Carrol 2002) that form the basis for sound salmon recovery efforts, including:

1) Set aside or protect the highest quality habitat
2) Prevent any further habitat degradation
3) Maintain and restore critical ecological processes
4) Develop goals and objectives based on thorough understanding of ecological processes and properties of the systems
5) Conserve and restore evolutionary processes
6) Manage in an adaptive manner that is minimally intrusive

Conservation of the existing quality habitat that supports core production and primary life history types — as well as quality migration habitats within populations and across the DPS — is the critical first step toward recovery. This needs to include a shared vision of desired ecosystem conditions that integrates ecological, socioeconomic, and institutional perspectives and identifies ways in which all parties can contribute to and benefit from achieving the desired ecosystem conditions. Protecting and restoring the normative natural ecological processes throughout the entire life cycle is essential for conserving the productive capacity of the habitat.

These principles provide general guidance but are difficult to apply specifically for prioritizing a broad list of actions at the population, major population group, and DPS levels. Because we have the need for criteria that deal with setting priorities across broad geographic and ecological scales, we propose more detailed prioritization considerations that are formulated from the broader conservation principles. In simplistic terms, the order of priority is first to protect and conserve high quality habitats and natural processes that currently support productive capacity and implement actions that provide immediate abundance and productivity benefits through reduction of key limiting factors and threats; second to enhance habitat and restore natural processes that are impaired but are currently important to productive capacity; and last to restore

habitat and natural processes that were historically important but do not currently contribute to productive capacity.

9.1.1 Prioritization Considerations

Setting priorities for management actions is difficult because of the scientific complexity and diverse policy issues and economic implications. Although priorities must be science based, they are ultimately policy choices. The following considerations are used as guidance and criteria for the development, prioritization, and implementation of management strategies and actions for recovery of Mid-C steelhead populations in Oregon.

We consider actions that achieve the following to be highest priority:

- Actions that provide long-term protection of habitat conditions and conservation of natural ecological processes that support the viability of priority extant populations and their primary life history strategies throughout their entire life cycle. A population is considered a priority if it is critical for MPG or DPS viability.
- Actions that protect or enhance viability of multiple steelhead populations.
- Actions that support conservation of unique and rare functioning habitats, habitat diversity, life histories and genetic attributes.
- Actions that target the key limiting factors and that contribute the most to closing the gap between current status and desired future status of priority populations.
- Actions that provide immediate benefits to enhancing the viability of priority populations.
- Actions that provide critical information needed for assessing success and making adaptive management decisions.

We consider the following types of actions to be high priority but less than highest:

- Actions that enhance the habitat conditions and restore natural ecological processes of priority extant populations and their primary life history strategies throughout the entire life cycle.
- Actions that enhance the viability across the entire life cycle of priority extant populations.
- Actions that are required to protect and enhance habitats for populations that are not critical for MPG or ESU viability but must be maintained.

Other things being equal, actions that demonstrate the following have enhanced priority:

- Actions where opportunity for success is high (rather than those of limited feasibility).
- Actions that likely produce a large (rather than small) improvement in viability attributes.
- Actions that support restoration of normative ecological processes rather than short-term substitutions for normative processes.
- Actions that are complementary to other land management, water quality, environmental management and recreational objectives as specified in fish management, conservation, recovery or other plans developed with and supported by regional and subbasin stakeholders (rather than those that are isolated, stand-alone efforts).

- Actions that have regional and local support and generate increased participation.
- Actions that demonstrate cost effectiveness relative to alternative means of achieving the same objectives.
- Actions that have high degree of certainty in effectiveness and outcome.

9.2 An Integrated Approach

In previous sections of this plan we identified delisting goals, broad sense recovery goals, current status and viability gaps, as well as limiting factors and threats across the entire life cycle. These elements serve as essential building blocks for identifying the strategies and actions needed to close viability gaps, reach delisting status, and progress toward our broad sense recovery goals.

The strategies and actions are developed to address the viability gaps and primary threats and factors currently limiting recovery of Oregon's Mid-C steelhead populations. Our integrated approach is designed to ensure that recovery efforts are developed and implemented in a scientifically sound and systematic manner. We strive to ensure that all recovery actions effectively complement and support each other in achieving the broad sense recovery goals.

Recovery strategies are designed to address the twelve types of factors discussed in Section 8, Limiting Factors and Threats, that affect steelhead viability throughout their entire life cycle. These factors fall into six different categories: tributary habitat; estuary/mainstem habitat; mainstem hydropower configurations and operations; in-subbasin and out-of-subbasin harvest; hatcheries; and predation and competition. Similarly, strategies and actions described in this section address threats and limiting factors in each of these categories. Table 9-1 illustrates the kinds of connections that exist between limiting factors, strategies, and actions.

The integrated approach is also intended to ensure that costs and consequences of achieving recovery are equitable across the affected constituencies. Recovery can be achieved with different combinations of actions implemented at different intensities among and on varying timelines. Thus, the plan defines expectations and direction for the various parties who will implement elements of the plan in a broader context of scientific, technical, economic, political, social, and cultural considerations. The plan also includes a strategic prioritization framework to provide flexibility for implementing parties to select, scale, and adapt regional and local strategies and actions to optimize effectiveness and efficiency in plan implementation, while also ensuring that steps toward recovery are consistent with regional goals and objectives.

Recovery of the Mid-C steelhead DPS is predicated on assumptions that: 1) remaining populations still retain the inherent characteristics needed to sustain healthy, harvestable levels when suitable conditions are provided; 2) declining trends can be reversed with appropriate actions; and 3) society is willing and able to implement appropriate strategies and their associated actions in a suitable timeframe. Guidance from the ICTRT recognizes that it may not be feasible, nor required, to protect and restore all existing populations to viable status. ICTRT criteria allow some populations to maintain status below viability standards. The plan assumes that a focused and broadly based effort will protect and restore a sufficient number of populations to ensure long-term viability and opportunities for harvest. This effort will require concerted and substantive action by people throughout the region.

Table 9-1. Integrated approach to address threats and factors limiting recovery of Oregon's Mid-Columbia River steelhead populations.

Strategies	Types of Actions	Limiting Factors and Threats Addressed
Tributary Habitat		
Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.	Protect highest quality habitats through acquisition and conservation. Adopt and manage Cooperative Agreements. Conserve rare and unique functioning habitats. Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	Degradation of tributary habitat-forming processes and functions (loss of channel structure, floodplain connectivity, riparian vegetation, and LWD recruitment)
Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	Provide passage at Pelton-Round Butte Complex. Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures. Provide screening at 100% of irrigation diversions. Replace screens that do not meet criteria.	Loss of historical habitat because of blocked or impaired fish passage (dams, culverts, unscreened diversions)
Maintain and restore floodplain connectivity and function.	Reconnect side channels and off-channel habitats to stream channels. Restore wet meadows. Reconnect floodplain to channel.	Degraded floodplain connectivity and function (loss of off-channel habitat, side channels, connected hypotheic zone)
Restore degraded and maintain properly functioning channel structure and complexity.	Place stable wood and other large organic debris in streambeds. Stabilize streambanks. Restore natural channel form.	Degraded channel structure and complexity (loss of spawning and rearing habitat, LWD, pools)
Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	Restore natural riparian vegetative communities. Develop grazing strategies that promote riparian recovery.	Degraded riparian condition (native riparian vegetative communities, LWD recruitment)
Restore natural hydrograph to provide sufficient flow during critical periods.	Implement agricultural water conservation measures. Improve irrigation conveyance and efficiency. Lease or acquire water rights and convert to instream.	Altered hydrology (low flow, scouring peak flows due to degraded watershed conditions, streamflow alterations and/or withdrawals for irrigation and other uses)
Improve degraded water quality and maintain unimpaired water quality.	Reduce chemical pollution inputs. Apply BMPs to animal feeding operations. Restore natural functions and processes through remediation actions.	Degraded water quality (high temperatures, nutrients, pesticides and other chemicals)
Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	Achieve 95% conversion to no till farming. Upgrade or remove problem forest roads. Restore native upland plant communities. Employ BMPs to forest practices, livestock grazing, road management and agricultural practices.	Altered sediment routing and runoff patterns due to upland management activities.
Estuarine and Plume Habitat		
Restore degraded estuarine and plume habitats and associated ecological processes	Protect/restore riparian areas Remove pile dikes Protect remaining high-quality off-channel habitat Breach or lower dikes and levees Identify and reduce sources of pollutants Monitor and restore contaminated sites	Degraded estuarine and nearshore marine habitat reduces refugia available to juvenile steelhead in Columbia River estuary and plume as they prepare for ocean life.
Hydropower Systems		
Operate the FCRPS to more closely approximate the shape of the natural hydrograph to enhance flows and water quality to improve juvenile and adult fish survival.	Draft storage reservoirs (Libby, Hungry Horse, Grand Coulee, and Dworshak) in attempt to meet seasonal and weekly flow objectives in the lower Columbia River during July and August. Pursue negotiations with Canada to provide 1 million acre feet of storage to augment summer flows. Meet Non-Treaty storage refill responsibilities and pursue a new long-term agreement on use of non-treaty space in Canadian reservoirs. Implement drafts and other measures to improve flows	Altered steelhead migration conditions and delayed passage due to hydrosystem development and operations in mainstem Columbia River.

Strategies	Types of Actions	Limiting Factors and Threats Addressed
	during the lowest 20th percentile years. Implement Water Quality Plan for Total Dissolved Gas and Water Temperature in the Mainstem Columbia and Snake rivers.	
Modify Columbia and Snake River dams to maximize juvenile and adult survival.	Implement project specific configurations and operations at the eight mainstem dams on the lower Snake and Columbia rivers.	Altered juvenile and adult steelhead migration conditions due to mainstem Columbia River hydrosystem.
Implement spill and juvenile transportation improvements at Columbia and Snake River dams.	Provide spill to improve juvenile fish passage. Implement interim transportation program to improve survival of transported fish.	Altered juvenile and adult steelhead migration conditions due to mainstem Columbia River hydrosystem.
Operate and maintain juvenile and adult fish passage facilities at Corps mainstem projects to maintain biological performance.	Corps will operate juvenile and adult passage facilities year around with the regionally coordinate Fish Passage Plan.	Altered juvenile and adult steelhead migration conditions due to mainstem Columbia River hydrosystem.
Restore sustainable natural steelhead production to blocked habitats in the Deschutes River Westside, Deschutes River Eastside and extinct Crooked River populations.	Develop downstream collection and passage through Pelton-Round Butte Complex. Improve flow patterns through reservoir for juvenile migration. Modify hydro operations to restore water quality.	Tributary hydrosystem operations and configurations block access to historical habitats and alter habitat conditions in Deschutes River system.
Improve hydrosystem operations and facilities to enhance steelhead survival and viability in the Umatilla and Walla Walla river systems.	Modify bypass flows at Boyd Project as needed to mimic instream water right. Modify fish passage facilities at Boyd Project to meet current standards. Remove weir panels from diversion dam at Boyd Project during non-operation. Maintain trash racks at Boyd Project. Modify fishway at Twin Reservoirs Project to meet juvenile fish passage standards.	Tributary hydrosystem operations and configurations impair passage and alter habitat conditions in the Umatilla and Walla Walla river systems.
Harvest		
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	Maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	Commercial, recreational and tribal fisheries in ocean, mainstem Columbia River and tributaries
Utilize tributary harvest to reduce abundance and proportion of stray hatchery spawners in Deschutes and John Day subbasins.	Develop educational outreach program to promote use of selective recreational fisheries to reduce the number of out-of-subbasin hatchery strays.	Straying of out-of-DPS hatchery spawners into tributary spawning grounds.
Reduce catch and release mortality on natural-origin fish in John Day subbasin.	Promote voluntary curtailment of fishing at higher water temperatures (above 21°C) to reduce hook-and-release mortality	Adverse effects of tributary harvest on natural steelhead in John Day subbasin.
Improve quality of harvest and natural-origin fish in John Day subbasin.	Expand the creel surveys to monitor fisheries effort and catch.	Adverse effects of tributary harvest on natural steelhead in John Day subbasin.
Hatcheries		
Reduce uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish.	Implement representative coded-wire-tagging program so all hatchery stocks have adequate CWT groups released annually. Recommend development of alternative broodstocks to reduce stray rates for programs that contribute significantly to stray problem.	Straying of out-of-DPS hatchery fish into natural spawning grounds.
Reduce uncertainty in abundance and proportion of hatchery strays spawning naturally with Fifteenmile, Deschutes Eastside and Lower John Day populations.	Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys and other methods.	Straying of out-of-DPS hatchery fish into natural spawning areas of Fifteenmile, Deschutes Eastside and Lower Mainstem John Day populations.
Reduce abundance and proportion of stray hatchery fish that spawn naturally with Deschutes Westside, Deschutes Eastside, Umatilla and	Construct, improve trapping facilities and expand operations. Eliminate adult hatchery strays above Nursery Bridge Dam.	Straying of out-of-DPS hatchery fish into natural spawning areas.

Strategies	Types of Actions	Limiting Factors and Threats Addressed
Walla Walla populations.		
Reduce genetic risks to Deschutes Westside population from Round Butte Hatchery Program.	Investigate opportunities and risks associated with incorporating naturally produced Deschutes River summer steelhead into RBH broodstock.	Inside-DPS hatchery genetic risks
Restore natural production into historically utilized habitats in the Deschutes Westside and Umatilla populations.	Develop plan for steelhead reintroduction into historical habitat above Pelton-Round Butte Complex when passage is restored. Re-establish natural production in Little Butter and Butter creeks and some minor spawning areas.	Risks related to steelhead reintroductions to historical habitat using inside-DPS hatchery fish.
Reduce genetic influence of hatchery fish in hatchery broodstock in the Umatilla subbasin.	Eliminate use of hatchery produced adults in the broodstock	Potential divergence in genetic and phenotypic traits between hatchery and natural-origin steelhead.
Reduce interactions between residual hatchery steelhead and natural steelhead in the Umatilla subbasin.	No consensus actions.	Risk of hatchery fish competing with and preying on natural steelhead juveniles
Reduce potential negative ecological interactions between coho salmon and natural steelhead in the Umatilla subbasin.	Reduce number of hatchery coho released in Umatilla River and relocate releases downstream to areas not currently important to steelhead production	Potential for coho smolts to compete with juvenile steelhead for prey resources and space
Predation and Competition		
Reduce predation and competition in the Columbia River mainstem, estuary and plume.	Reduce predation by pinnipeds Redistribute Caspian terns Redistribute cormorants	Increased predation on steelhead due to degraded estuarine and plume habitats, and to hydrosystem development and operations in mainstem Columbia River.

9.2.1 Building on Current Efforts

We recognize that many steps have already been taken or are currently underway that will improve the status of different Oregon Mid-C steelhead populations. In tributary watersheds state and federal natural resource managers, tribes, local governments, watershed councils, soil and water conservation districts, non-profit organizations, local land owners and others continue to improve stream conditions to support viable steelhead populations throughout their freshwater life stages. They are also improving land use practices on uplands and floodplains that are allowing natural ecosystem functions and processes to recover. State of Oregon Forest Practices Rules were adopted in 2002 and provide improved protection through a variety of guidelines. The rules address roads built in critical locations, and in addition, private landowners implement voluntary actions to address conditions on roads built prior to 2002. Private forest landowners have experienced disincentives to active placement of large wood in the past. A recent decision has led to the ability of private landowners to place large wood under the authority of the Oregon Forest Practices Act without additional permits. This streamlined process has renewed landowner enthusiasm to place large wood. Federal lands are managed under PACFISH and Northwest Forest Plan guidelines. These guidelines provide significantly improved protection and restoration standards on federal lands.

Oregon Water Resources Department has made progress in enhancement of streamflows. Live surface flow is closed to new appropriations in 99% of the Mid-C area during the low flow period in the month of August. To date, 1,760 stream miles are protected by in-stream water rights, and in 2006, 85 cfs was restored to Mid-C streams. Interest in voluntary flow restoration is gradually increasing.

To illustrate the magnitude of effort that is underway and the types of projects completed, we compiled a list of habitat projects that have been implemented in each population on all types of lands over the past 11 years (Appendix C). Similar efforts are underway in the Columbia River estuary that will improve estuarine and plume habitats and reduce predation (Appendix D). In the mainstem Columbia River, hydrosystem managers and fish resource mangers continue to refine hydropower system operations to address the needs for survival and recovery of the Mid-C steelhead DPS and other ESA-listed salmon and steelhead. Many hydropower configuration and operational improvements have been implemented in recent years that have provided survival benefits for Mid-C steelhead (Appendix D). In the Hydro BiOp remand process, new hydropower configuration and operational improvements are proposed.

Hatchery programs operated within the DPS have been modified substantially over the past 10 years to reduce threats and improve contribution to recovery. Programs have been reduced in scope, release locations have been modified, and considerable emphasis has been placed on assessing the source and potential impacts of strays. As described earlier, extensive harvest management changes in both the mainstem and tributaries have been implemented to reduce the impacts of fisheries.

This plan is designed to build upon past and current efforts that are already improving population viability and habitat conditions. Many of these efforts are described in the plan along with their sufficiency and gaps so that future actions expand from and improve the effectiveness of the efforts. Spreading the responsibility among a range of parties lessens the cost to any one group, increases the certainty of success, and compounds the benefits of moderate improvements in each factor.

Together, the strategies and actions identified in the following subsections outline an integrated approach that will support the viability of Oregon's Mid-C steelhead populations and their primary life history strategies throughout their life cycle. These strategies and actions are designed to address threats to population viability from tributary habitat degradation, estuarine and nearshore marine habitat degradation, the Columbia River hydropower system, harvest management, hatchery management, and predation.

9.3 Tributary Habitat Strategies and Actions

The suites of strategies and actions proposed in this section will protect and improve ecosystem functions and restore normative ecological processes to levels that support recovery of Oregon's Mid-C steelhead populations. The strategies and actions were developed by planning teams comprised of natural resource specialists for the Fifteenmile, Deschutes, John Day, Umatilla and Walla Walla watersheds. The actions reflect direction identified in related regional and local plans, recent modeling and research findings, and local expert input provided by the planning team members. Together, these strategies and actions call for maintaining high quality habitats and their productive capacity, improving ecosystem processes and habitats that are impaired but are currently important to productive capacity, and habitat restoration through passive and active measures. The strategies and actions represent a complete list of needs, somewhat unconstrained by logistic and financial concerns.

- Protection of existing high quality habitats is a broad economical approach of ensuring no net loss in habitat quality and maintenance of normative ecological processes. Many objectives are likely to be met through habitat protection and the associated natural recovery of upland and riparian areas. Land acquisitions, easements, cooperative agreements, and protective land designations facilitate the accomplishment of high quality habitat protection.

- Maintaining improved habitats and halting further degradation in habitats that are not at desired condition but are still important to productive capacity is an important element of habitat management. Changes resulting from improved land use practices can be an important element to improve habitat management and ecosystem function. Education, comprehensive land use planning, and regulations can provide habitat protection and support ecosystem functions by managing growth and land use so that critical habitats and watershed functions are preserved. Those that are integrated with social and economic goals while providing desired protection are most sustainable.

- Broad opportunities exist to improve habitat conditions for Mid-C steelhead populations through restoration. The success of these strategies is enhanced when actions build from existing restoration efforts, incorporate a range of project types that address the many interrelated habitat impairments, and take into account socioeconomic and institutional perspectives. Generally, our strategies and actions stress passive approaches to restoration (such as changes in grazing management that promote riparian recovery) over active restoration (manual placement of structures) as the preferred approaches to overall habitat restoration. In some areas, regulations are expected to provide passive restoration; however, we recognize that riparian function may take a long time to fully recover. Active restoration can provide improvements in some cases while natural processes are being restored through passive approaches.

We defined eight tributary habitat strategies that are directly linked to the limiting factors. We organized the habitat actions and associated information for each population by the habitat strategies:

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

For each strategy, we examined key programs that currently contribute to actions that serve to achieve the strategy, as well as the sufficiency of the existing programs. We identified specific actions needed to fill the gaps between what is currently being implemented and what is needed in the long term to fully achieve the strategy. Actions differ from strategies in that they address specific needs for a specified geographic area, program deficiencies, as well as biophysical habitat impairments and threats.

We also identified priority areas and actions for each population based on relative importance in meeting local and regional recovery objectives for Mid-C steelhead (Figure 9-1). Priority 1 reaches represent the habitats where management actions will yield the greatest benefits towards improving the viability. The strategic guidance provided earlier in this section served as the basis for identifying priority areas and actions within each population. We realize that the result of our process is a long list of priority 1 and priority 2 habitat actions for each population. We view the population specific implementation plans as the vehicles for developing the specific time and place roadmap for implementation of priority actions. We recognize there is repetition in the actions between populations. We envision local groups using the individual population action tables for development of specific implementation plans.

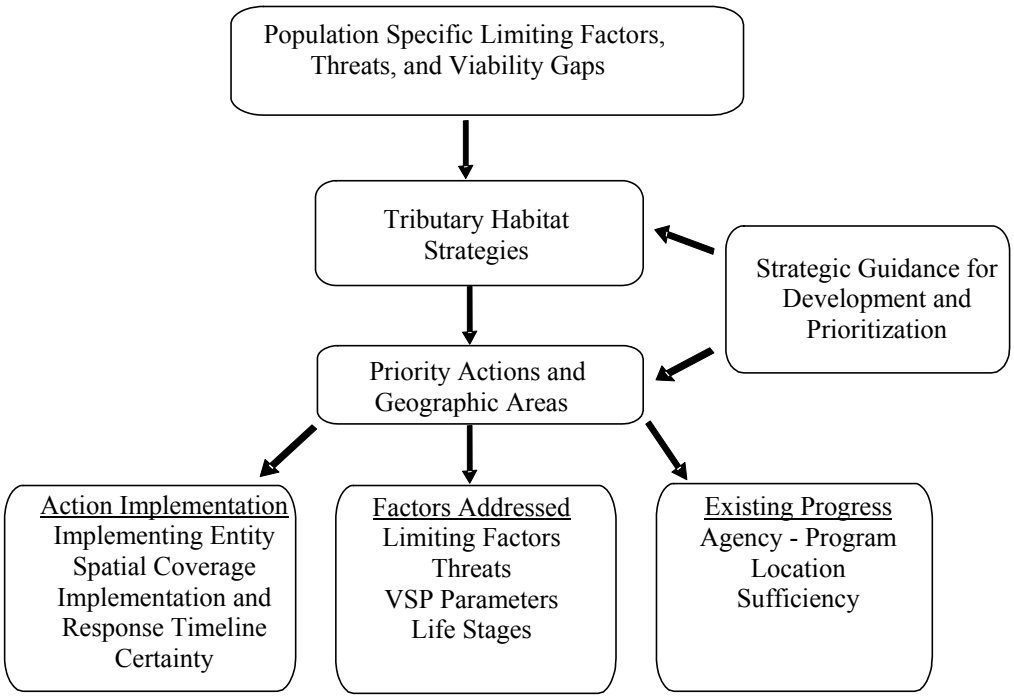


Figure 9-1. Flow chart illustrating the process for development of tributary habitat strategies, actions, and programs and their characteristics.

The following tables show strategies and actions needed to address tributary habitat limiting factors and threats for Oregon Mid-C steelhead populations. The tributary habitat strategies are not presented in priority order. Strategy tables for each population identify specific actions, limiting factors and threats addressed, and viability parameters and life stages that are most affected. Individual actions are described in terms of the status of current efforts, implementing entities, strategies addressed, spatial coverage, implementation timeframe, expected biophysical response timeframe and certainty of outcome. Priority locations are stream reaches or areas where actions should be implemented first to achieve the greatest benefit. Education and outreach actions are discussed in the first strategy only; however, they need to be applied to the implementation of all eight of the habitat strategies for all populations.

The tables also identify key programs that are currently implementing actions and discuss program sufficiency and gaps. Program sufficiency, sufficiency rationale, and program improvement needs for State of Oregon programs and most Federal programs were assessed through a formal process conducted by the State of Oregon and the Federal entities. These reviews resulted in independent reports that were then used to compile the sufficiency information in the action tables. The Oregon State Agencies program sufficiency report is not finalized; therefore, the actual sufficiency ratings were not available for use in this document. However, rationale related to the strengths and weaknesses of the State Agency programs is available and appended to this plan. For the non-state and non-federal programs, as well as federal programs that were not reviewed in the USFS/BLM Program Sufficiency Assessment, program sufficiency was assessed by the management action teams in cooperation with the implementing entities. Program sufficiency assessments are difficult to conduct. In many cases the legal mandates of a specific program were not necessarily developed for the purposes of recovering steelhead. The conclusions of an assessment can be biased when the assessment is conducted by the managers of the program for a variety of reasons. Unbiased outside reviews are probably the best approach, but can be very costly and take considerable time. We caution readers not to place too much emphasis on the sufficiency ratings themselves. We view the value of the sufficiency assessments primarily in characterizing the constraints, types of improvements, and modifications that would result in improved effectiveness of programs contributing to recovery of Mid-C steelhead.

9.3.1 Habitat Strategies and Actions for Fifteenmile Creek Steelhead Population

Primary limiting factors: low flows, high water temperatures, sedimentation, channel confinement, impaired riparian ecosystems, and reduced habitat quality.

Primary threats: roads, residential development, agricultural practices and forest uses.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect the highest quality habitats through acquisition or conservation measures	1-Fifteenmile Cr. (Hwy 197 upstream to FS boundary) 1-Eightmile Cr. (Hwy 197 upstream to FS boundary) 1-Ramsey Cr. (mouth to FS boundary) 2-Fivemile Creek from Hwy 197 upstream to headwaters.	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	All	All	Protecting high quality habitats is the most cost effective way to ensure fish have good quality habitat. It is much less expensive over the long term to protect high quality habitat than it is to degrade the habitat and then try to restore it. Protection of existing high quality habitat areas is a broad strategy capable of contributing to meeting all of biological habitat objectives. Land acquisitions, easements, and cooperative agreements will facilitate the implementation of protection and conservation.
Protect and conserve rare and unique functioning habitats	Considering the unique winter life history form present for the MaSA, and no other winter steelhead in DPS, they are all unique. Entire MaSA 1-South Fork Mill Cr. (Water treatment to falls)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	All	All	Protecting high quality unique habitats is the most cost effective way to ensure fish have good quality habitat. South Fk. Mill Creek from water treatment plant to falls is in pristine condition. One of few areas in the MiSA that remains pristine.
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	1-Fifteenmile Creek MaSA and MiSA	All factors	All	All	All	To prevent habitat degradation BMPs and existing laws that protect habitat should be applied throughout the population.
Conduct outreach to resource users and managers	1-Entire population	All factors	All	All	All	Program efficiencies will be improved through increased knowledge and understanding of the importance of habitat conditions and land use practices.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation measures.	CTWSRO, ODFW, SWCD, USDA FSA, land trusts, NGOs	Ongoing	Population-wide	Existing conservation agreements are complete. Full implementation of conservation measures will take 25 years or more	Conservation benefits are immediate	High
Protect and conserve rare and unique functioning habitats.	Land trusts, CTWSRO, ODFW, SWCD, NGOs, USFS	Ongoing	Population-wide	Immediate	Immediate	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	SWCD, USFS, private landowners, ODA, CTWSRO	Ongoing	Population-wide	Long term	Degradation prevention immediate, improved conditions 15-25 years	High
Conduct outreach to resource users and managers.	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS	Fifteenmile Riverkeeper	USFS lands and non-forest lands under Wyden Amendment Authority	Likely	Positive results where the program has been implemented, but it could be expand to more forest lands in the population, and become more available off forest lands. Contingent on year to year funding appropriations
ODFW	Fifteenmile Creek Fish Habitat Restoration Project	Private lands throughout population	No	Positive results where the program has been implemented, but funding and landowner cooperation limits the amount of available projects. In addition, limited legal guarantees that landowners remain in program.
USFS	Northwest Forest Plan	All Mt. Hood National Forest lands	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
Wasco County SWCD/USDA FSA	CREP, CRP	Private riparian areas and qualified uplands throughout population	Uncertain	Both programs are effective at protecting riparian areas and uplands, however additional lands need to be enrolled. CRP program is near capacity for Wasco County. Some landowners reluctant to enter the federal programs. See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust or other entity	Lease or purchase instream water rights	Fifteenmile, Eightmile, Fivemile MaSA	No	Program has been effective at obtaining water rights, but maintaining water instream to the mouth of the river is difficult. Many landowners reluctant to enter into program. It is important to secure water rights to guarantee instream flow.
Wasco County SWCD	No-till Conversion	Uplands throughout population		An effective program at reducing erosion, but needs to be expanded to additional properties.
OWEB	Watershed Councils	Fifteenmile and The Dalles		See State of Oregon programmatic review -- Appendix F.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
		watershed council		
ODA	Agricultural Water Quality Management Program	Fifteenmile population unit		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Tribal lands on Fifteenmile Creek	No	Various programs designed to improve riparian, stream, and upland conditions along tribal lands. Additional restoration and protection efforts are needed.
ODF	Oregon Forest Practices Act	Private and state forestlands in Fifteenmile, Eightmile, Ramsey , and Fivemile creeks		See State of Oregon programmatic review – Appendix F.
Local Government, irrigation districts	City and County Planning and Zoning	Private lands throughout the entire population	Yes	Compliance with zoning requirements is high
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Many programs already in place in the subbasin are designed to restore physical habitat. These programs have proven effective, but it will take years to return the stream to a more natural condition. Existing forest plans include special management designations for riparian reserves. Adding additional wilderness areas and wild and scenic river segments would require designation by Congress. The forest plans and BLM plans have been amended by the Northwest Forest Plan that requires riparian reserve boundaries of two site potential tree heights on both sides of any fish bearing stream and contains very restrictive standards and guidelines to ensure protection of aquatic and riparian resources. Compliance with riparian reserve standards and guidelines for a variety of land use activities including forest practices operations, cattle grazing, and others has been very good. Farm Service Agency (FSA) programs that protect riparian areas and upland watersheds include the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). The CRP program pays landowners not to farm highly erodible soils and the CREP program pays landowners for setting riparian corridors aside from grazing and farming. The long term effectiveness of both programs is limited by the relatively short duration of the contracts which ranges from 10 to 15 years. ODA's Agricultural Water Quality Management Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements.				

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Replace barriers blocking passage including dams, road culverts and irrigation structures	1-Barriers that limit adult access: Ramsey Creek (culvert FS 4450 Rd), Ramsey Creek (Olsen Irrigation Diversion RM 3.5), Fifteenmile Tenold Diversion (RM 2.0), Culvert at FS Rd. 44, Dam at Boys Scout Camp Baldwin on Ramsey Creek (RM 11.0) 2-Barriers that limit juvenile access: Fifteenmile same as adults Threemile Creek (Hwys. I-84 & 197) Chenowith Creek Bridge at Hwy. 30 Fixed Long, Douglas, Standard Hollows Mays Canyon	Impaired fish passage	Dams, culverts, instream structures	Spatial structure, productivity	Primarily adults and 0+juveniles	Spatial structure of the Fifteenmile winter steelhead population has been modified and restricted by culvert barriers and hostile environmental conditions in the middle and lower elevations (NPCC 2004).
Provide screening at 100% of irrigation diversions	1-Additonal survey needed to identify unscreened diversions	Impaired fish passage	Irrigation diversions	Spatial structure,	Primarily adults and	Known diversions are screened to criteria.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
	2-All known diversions are screened in the Fifteenmile MaSA.			productivity	0+juveniles	
Replace screens that do not meet criteria	1-Additional survey needed 2-Fifteenmile all known screens meet criteria.	Impaired fish passage	Irrigation diversions	Spatial structure, productivity	Primarily adults and 0+juveniles	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Replace barriers blocking passage including dams, road culverts and irrigation structures	USFS, SWCD, ODFW	Ongoing	At barriers	Ongoing	Immediate	High
Provide screening at 100% of irrigation diversions	ODFW, BPA, NOAA Fish	Ongoing	At point of diversion	All legal diversions screened in Fifteenmile. Need further survey work to determine number of screens in other areas	Immediate	High
Replace screens that do not meet criteria	ODFW, BPA, NOAA Fish	Ongoing	At point of diversion	Legal diversion meets criteria. Need further survey work in MiSA to determine number of screens	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	Fish Passage/Screening—State and Federal funded programs	Unscreened or poorly screened diversions throughout population	Uncertain	Continued funding of federal program is uncertain. New and replaced screens are sufficient. See Appendix F for State program review.
ODOT	Culvert replacement or retrofit	Threemile Creek culvert at Hwy. I-84 and Hwy. 197; Chenowith Creek Bridge at Hwy. 30		See State of Oregon programmatic review -- Appendix F.
USFS	Culvert replacement	USFS lands	Likely	Funding and priority of programs is uncertain. Timeframe for completing work uncertain.
Wasco County Road Department, OWEB, Wasco County SWCD	Culvert replacement	North Fk Mill Creek (RM 6.0)		Funding and priority of programs is uncertain. See State of Oregon programmatic review -- Appendix F.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
The technology to provide sufficient passage conditions with screens and culverts is available and in use. Programs implementing these improvements are generally underfunded thus resulting in uncertain sufficiency ratings. The Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) provides guidance that will help prioritize culvert replacements for this population.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary)	Degraded floodplain, altered hydrology, altered	Removal of wetlands, side channels, off-stream	Abundance, productivity,	Primarily fry, summer parr,	Floodplains and channels that are in balance are essential for proper

Strategy 3. Maintain and restore floodplain connectivity and function.						
	1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters) 2-Mill Cr.(Mouth to North Fork) 2-North Fk. Mill Cr. (mouth to FS boundary)	sediment routing, degraded water quality	habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	spatial structure	winter parr	stream function.
Reconnect side channels and off-channel habitats to stream channels	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters) 2-Mill Cr.(Mouth to North Fork) 2-North Fk. Mill Cr. (mouth to FS boundary)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity, spatial structure	Primarily fry, summer parr, winter parr	Side channels provide habitat for spawning and rearing and refugia from high flows.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	Population-wide	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity, spatial structure	Primarily fry, summer parr, winter parr	Beaver have started to recolonize many areas in the watershed.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain habitats	ODFW, watershed council, SWCD, USFS Riverkeeper	Ongoing	Improved connectivity with channel will be localized; improved water table will increase streamflow and lower water temperatures downstream.	Long term	5-15 years	Moderate
Reconnect side channels and off-channel habitats to stream channels	ODFW, watershed council, SWCD, USFS Riverkeeper	Ongoing	Improved connectivity with channel will be localized; improved water table will increase streamflow and lower water temperatures downstream.	Long term	5-15 years	Moderate
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	ODFW, USFS	Ongoing		Long Term	5-15 years	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS	Fifteenmile Riverkeeper	USFS lands and non-forest lands under Wyden Amendment Authority	Likely	Positive results where the program has been implemented, but it could be expanded to more forest lands in the population, and become more available off forest lands. Contingent on year to year funding appropriations.
ODFW	Fifteenmile Creek Habitat Restoration Project	Private lands in MaSAs from forest service boundary downstream to mouth.	No	Additional projects may be available. Funding may be an issue.
ODF	Oregon Forest Practices Act	Private and state forestlands in Fifteenmile, Eightmile, Ramsey , and Fivemile Creeks		See State of Oregon programmatic review -- Appendix F.
Wasco SWCD	Watershed restoration	Areas from forest service boundary		Conservation protection and outreach measures needed

Strategy 3. Maintain and restore floodplain connectivity and function.				
		downstream		on private lands. See State of Oregon programmatic review -- Appendix F.
ODA	Agricultural Water Quality Management Program	Fifteenmile population unit		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Reservation lands	No	Various programs designed to improve riparian, stream, and upland conditions along tribal lands. Additional restoration and protection efforts are needed.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters) 2-Mill Cr.(Mouth to North Fork) 2-North Fk. Mill Cr. (mouth to FS boundary)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature, flows	Stream channelization, berming, bank armoring, large wood removal, beaver removal, overgrazing in riparian areas	Abundance, productivity	Primarily egg, alevins, fry, summer parr, winter parr	Fifteenmile has been extensively channelized and straightened and has subsequently downcut. Historical aerial photos indicate that the stream is shorter and steeper now than before the 1970s (NPCC 2004).
Increase role and abundance of wood and large organic debris in streambeds	1- Fifteenmile Cr.(Mouth to City of Dufur intake) 1-Eightmile Cr. (Hwy 197 to Walston Grade (RM19.0)) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal	Abundance, productivity	Primarily egg, alevins, fry, summer parr, winter parr	Many legacy effects of past land use practices continue to affect channel form and instream habitat. Current practices have less effect.
Increase instream habitat through manual placement of structures	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters) 2-Mill Cr.(Mouth to North Fork) 2-North Fk. Mill Cr. (mouth to FS boundary)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal	Abundance, productivity	Primarily egg, alevins, fry, summer parr, winter parr	Considered an active form of restoration while habitat conditions are restored through more passive efforts. Limited opportunities exist in reaches identified.
Stabilize streambanks	Limited areas throughout population	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily egg, alevins, fry, summer parr, winter parr	Most actively eroding banks have been protected.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCD, USFS, BPA, OWEB, CTWSRO	Expansion of existing efforts	Local to treatment area	Ongoing	Increased habitat diversity (0-10 years)	High
Increase role and abundance of wood and large organic debris in streambeds	ODFW, USFS	Expansion of existing efforts	Local to treatment area	Ongoing	Increased habitat diversity (0-10 years)	High
Increase instream habitat through manual placement of structures	ODFW, USFS	Expansion of existing efforts	Local to treatment area	Ongoing	Increased habitat diversity (0-10 years)	High
Stabilize streambanks	ODFW, SWCD, USFS	Expansion of existing efforts	Local to treatment area	Ongoing	Increased habitat diversity (0-10 years)	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS	Fifteenmile Riverkeeper	USFS lands and non-forest lands under Wyden Amendment Authority	Likely	Positive results where the program has been implemented, but it could be expanded to more forest lands in the population, and become more available off forest lands. Contingent on year to year funding appropriations.
USFS	Northwest Forest Plan	All Mt. Hood National Forest lands	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
ODFW	Fifteenmile Creek Habitat Restoration Project	Private lands in population from forest service boundary downstream to mouth	Uncertain	Additional projects may be available. Funding may be an issue.
ODF	Oregon Forest Practices Act	Private and state forestlands in Fifteenmile, Eightmile, Ramsey , and Fivemile creeks		See State of Oregon programmatic review -- Appendix F.
Wasco SWCD	Watershed restoration	Private agricultural lands		Additional opportunities exist for projects, outreach, and education. See State of Oregon programmatic review -- Appendix F.
ODA	Agricultural Water Quality Management Program	Private agricultural lands		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Reservation lands	No	Various programs designed to improve riparian, stream, and upland conditions along tribal lands. Additional restoration and protection efforts are needed.
OWEB	Watershed Councils	Private lands population-wide		See State of Oregon programmatic review -- Appendix F.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The Forest Service Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funds where it is most needed.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian communities including vegetative planting	1-Eightmile Cr (RM 7 upstream RM 17 mostly complete, some opportunities exist) 1-Fivemile Cr. Hwy 197 to RM 5, RM 7 upstream to FS boundary) 2-Fifteenmile Cr. (Mostly fenced or protected from livestock in recovering condition.) 2-Mill Cr. (mouth to forks)	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Livestock grazing, agricultural conversion, roads, urban development, loss of beaver dams	Abundance, productivity	All	Riparian areas have been altered throughout the subbasin. Many areas are recovering through newly implemented conservation practices. Approximately 126 miles of stream are currently protected through some form of riparian buffer. Additional opportunities for conservation easements exist. Primary methods of riparian enhancement include riparian corridor fences to exclude livestock while controlling weeds, changes in grazing management that promote riparian recovery, and planting of native shrubs.
Develop grazing strategies that promote riparian recovery	1-Eightmile RM 8.5 2-USFS grazing allotments	Bank degradation, degraded riparian communities, flow, sediment routing	Livestock grazing	Abundance, productivity	All	Area of heavy grazing by horses. The USFS has several grazing allotments in headwater areas of several streams.
Eradicate invasive plant species from riparian areas	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Dry Cr.(Mouth to headwaters) 1-Ramsey Cr. (Mouth to FS boundary) 1-Eightmile Cr (Mouth to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary)	Degraded riparian communities	Conversion of natural riparian vegetative communities	Abundance, productivity	All	Riparian lease agreements with ODFW and CREP programs require control of noxious weeds.
Install fencing to exclude livestock from riparian areas	1-Eightmile Cr (RM 7 upstream RM 17 mostly complete, some opportunities exist) 1-Fivemile Cr. Hwy 197 to RM 5, RM 7 upstream to FS boundary) 2-Fifteenmile Cr. (Mostly fenced or protected from livestock in recovering condition.) 2-Mill Cr. (mouth to forks)	Bank degradation, degraded riparian communities, flow, sediment routing	Livestock grazing	Abundance, productivity	All	A considerable amount of riparian fencing has been completed in the population unit, however, some opportunities remain. Long term maintenance of riparian fence is needed.
Install off-stream livestock watering	1-Fifteenmile Cr. (4 sites in Dufur Valley, multiple sites mouth to Hwy 197) 1-Eightmile Cr. Multiple sites needed 1-Fivemile Cr. Multiple sites needed 2-Ramsey Cr. Multiple sites needed 2-Dry Cr. Some sites available	Degraded riparian communities, sediment routing	Livestock grazing	Abundance, productivity	All	Off-stream watering sites reduce livestock impacts on stream banks. Many solar and other innovative techniques are currently being deployed.
Plant riparian vegetation where appropriate		Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Livestock grazing, agricultural conversion,	Abundance, productivity	All	Natural vegetation restoration generally occurs without planting, some planting occurs along with fencing projects and CREP projects.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
			roads, urban development			

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian communities including vegetative planting	ODFW,SWCD, NRCS, FSA, ODF	Expansion of existing efforts	Within treated area and downstream	Ongoing	Riparian restoration (10-25 years)	High
Develop grazing strategies that promote riparian recovery	ODA, SWCD, NRCS, USFS	Unknown	Within treated area	Ongoing	Riparian restoration (10-25 years)	Moderate
Eradicate invasive plant species from riparian areas	ODFW, SWCD, Wasco County, USFS	Expansion of existing effort	Within treated area	Ongoing	Immediate	High
Install fencing to exclude livestock from riparian areas	ODFW, SWCD, CTWSRO, NRCS, FSA	Expansion of existing effort	Within treated area and downstream	Ongoing	Riparian restoration (10-25 years)	High
Install off-stream livestock watering	ODFW, SWCD, NRCS, FSA	Expansion of existing effort	Within treated area and downstream	Ongoing	Riparian restoration (10-25 years)	High
Plant riparian vegetation where appropriate	ODFW, SWCD, FSA	Expansion of existing effort	Within treated area and downstream	Ongoing	Riparian restoration (10-25 years)	Moderate

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Wasco SWCD	Watershed restoration including all actions	Private agricultural lands		Additional opportunities exist for projects, outreach, and education. See State of Oregon programmatic review -- Appendix F.
USDA FSA, SWCD, NRCS	CREP	Qualified private riparian areas throughout population	No	Effective at protecting riparian areas, however additional lands need to be enrolled. Some landowners reluctant to enter the federal programs.
ODFW	Fifteenmile Creek Fish Habitat Restoration Project	Private lands throughout population	No	Positive results where the program has been implemented, but funding and landowner cooperation limits the amount of available projects. In addit ion, limited legal guarantees that landowners remain in program.
USFS	Fifteenmile River keeper	USFS lands and non-forest lands under Wyden Amendment Authority	Likely	Positive results where the program has been implemented, but it could expand to more forest lands in the population, and become more available off forest lands. Contingent on year to year funding appropriations.
USFS	Northwest Forest Plan	All Mt. Hood National Forest lands	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
ODA	Agricultural Water Quality Management Program	Private agricultural lands		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Reservation lands	No	Various programs designed to improve riparian, stream, and upland conditions along tribal lands. Additional restoration and protection efforts are needed with additional funds.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.				
ODF	Oregon Forest Practices Act	Private and state forestlands in Fifteenmile, Eightmile, Ramsey , and Fivemile Creek		See State of Oregon programmatic review -- Appendix F.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Constant maintenance of the fence lines must be conducted to keep livestock out and protect the riparian vegetation. Construction of more off channel watering sites or water gaps would help to address part of the issue. The Forest Service Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funds where it is most needed.				

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary)	Altered hydrology, low flows, high temperatures	water withdrawals, land conversion on uplands, road network	Abundance, productivity	Primarily fry and summer parr	EDT results indicate that high and low flows reduce steelhead populations in every reach (NPCC 2004).
Improve irrigation conveyance and efficiency	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary)	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Primarily fry and summer parr	Considerable water savings may be possible by utilizing new technology irrigation.
Finish piping Orchard Ridge and Wolf Run diversions	1- Fifteenmile Cr (Orchard Ridge) 1- Eightmile Cr (Wolf Run)	Impaired flows	Irrigation diversions	Spatial structure, productivity	primarily adults and 0+juveniles	Open ditches lose considerable water through evaporation and leakage.
Implement urban conservation measures	1-Mill Creek (City of The Dalles) 2-Fifteenmile Cr. (City of Dufur)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	All	Much of the flow of Mill Creek is utilized for domestic drinking water.
Lease or purchase water rights and convert to instream	Population-wide.	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	Program has been effective when rights have become available. Senior rights generally not available. Many landowners reluctant to sell water rights.
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	Annual fluctuations in flow levels are intensified by irrigation withdrawals
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

strategies to meet long-term needs						

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD	Expands existing program, proposes new projects	Point of diversion downstream	Ongoing	Immediate increase in streamflow	High
Improve irrigation conveyance and efficiency	SWCD, USFS, OWRD, OWEB landowners	Expands existing program, proposes new projects	Agricultural lands throughout subbasin	Ongoing	Increased streamflow (0-5 years)	High
Finish piping Orchard Ridge and Wolf Run diversions	SWCD, USFS	Expansion of existing project	Upper Fifteenmile and Eightmile	Unknown	Potentially less water diverted as a result of water savings.	High
Implement urban conservation measures	SWCD, City of The Dalles	Expands existing program, proposes new projects	Mill Cr. MaSA	Ongoing	Immediate increase in instream flow, however, increases may be moderated by urban growth and increased demand.	High
Lease or purchase water rights and convert to instream	OWRD, Oregon Water Trust, others	Ongoing	Population-wide	Unknown	Immediate increase in instream flow	High
Monitor/regulate water withdrawals	OWRD	Ongoing	Population-wide	Ongoing		High
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS	Fifteenmile Riverkeeper	USFS lands and non-forest lands under Wyden Amendment authority	Likely	Positive results where the program has been implemented, but it could be expanded to more forest lands in the population, and become more available off forest lands. Contingent on year to year funding appropriations.
USFS	Northwest Forest Plan	All Mt. Hood National Forest lands	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW	Fifteenmile Creek Fish Habitat Restoration Project	Private lands throughout Fifteenmile population	No	Positive results where the program has been implemented, but funding and landowner cooperation limits the amount of available projects. In addition, limited legal guarantees that landowners remain in program.
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Population-wide		See State of Oregon programmatic review -- Appendix F.

Oregon Water Trust or other entity	Lease or purchase instream water rights	Fifteenmile, Eightmile, Fivemile MaSAs	No	Program has been effective at obtaining water rights, but continually to maintain water instream to the mouth of the river is difficult. Many landowners have been reluctant to enter into program in past, but recently program is increasingly popular. Yes, important to secure water rights to guarantee instream flow.
USFS, Wasco Co. SWCD, NRCS, OWEB	Irrigation conveyance efficiency	Population-wide	USFS likely	Piping open ditches and other efficiency projects will decrease irrigation demand on streams. Program could be expanded to many additional irrigators. See State of Oregon programmatic review -- Appendix F for SWCD and OWEB.
Wasco Co. SWCD	No-till conversion, watershed restoration	Uplands population-wide		Program has proven effective at reducing erosion, but additional lands could be enrolled. See State of Oregon programmatic review -- Appendix F.
Wasco County SWCD/USDA FSA	CREP, CRP	Private riparian areas and qualified uplands throughout population	Uncertain	Both programs are effective at protecting riparian areas and uplands, however additional lands need to be enrolled. CRP program is near capacity for Wasco County. Some landowners reluctant to enter the federal programs.
CTWSRO	Watershed Restoration	Tribal lands	No	Various programs designed to improve riparian, stream, and upland conditions along tribal lands. Additional restoration and protection efforts are needed.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Peak flows are mitigated via upland vegetation, channel and riparian complexity, and closure of excess roads, particularly those with insufficient drainage. Highly successful programs now address upland and riparian conditions. Programs addressing channel complexity and road closure have, to date, only addressed a small portion of the watershed. Low summer flows are affected by the same factors that affect peak flows, but are more directly affected by irrigation withdrawals from the stream and associated aquifers. Programs have addressed irrigation efficiency on some but not all farms. They have addressed conveyance efficiency on the Wolf Run Ditch, but not the Orchard Ridge Ditch. Few if any efficiency programs have resulted in conversion to instream water rights. Fifteenmile Creek has 124 miles of stream protected by instream water rights. Voluntary restoration projects restored approximately 8.6 cfs in 2006.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Manage irrigation return flow to reduce extreme stream temperatures	1-Fifteenmile(Underhill return diversion)	Altered stream temperatures, degraded water quality	Water withdrawals	Abundance, productivity	Fry dispersal and rearing	Excessive summer temperatures have been identified as a major limiting factor for Fifteenmile Creek. Temperatures often approach or exceed lethal levels for salmonids in some of the subbasin.
Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary)	Depleted oxygen		Abundance, productivity	Fry dispersal and rearing	Warm temperatures reduce the dissolved oxygen capacity of the water.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
	2-Dry Cr.(Mouth to headwaters) 2-Mill Cr.(Mouth to North Fork) 2-North Fk. Mill Cr. (mouth to FS boundary)					
Reduce chemical pollution inputs	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Mouth to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters) 2-Mill Cr.(Mouth to North Fork)	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity		Amounts of chemical pollution reaching streams are unknown and need to be determined. Widespread use of chemicals is common in agricultural practices near streams. Reduced streamflow may accentuate pollution.
Implement Agricultural Water Quality Management Plan	1-Fifteenmile Cr. (Mouth to FS boundary) 1-Ramsey Cr. (Mouth to new FS boundary) 1-Eightmile Cr. (Hwy 197 to FS boundary) 1-Fivemile Cr. (Mouth to FS boundary) 2-Dry Cr.(Mouth to headwaters)	Degraded upland processes, altered hydrology, water quality, altered sediment routing	Land conversion and agricultural practices	Abundance, productivity	Fry dispersal and rearing	Recent conservation measures have greatly reduced sediment inputs; however, sedimentation remains elevated beyond historical conditions. Fifteenmile and Ramsey creeks are on the 303(d) list for sedimentation and EDT modeling identified sedimentation as a key factor limiting steelhead production.
Continue TMDL monitoring	Population-wide	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	All	
Acquire conservation easements or agreements, and important habitats when available.	Significant properties when they become available.	All	All	Abundance, productivity	All	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Manage irrigation return flow to reduce extreme stream temperatures	ODEQ, OWR, SWCD	Ongoing	Subbasin-wide	Ongoing	0-5 years	High
Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	ODEQ, SWCD, FSA, NRCS, ODFW	Ongoing		Ongoing	0-5 years	Moderate
Reduce chemical pollution inputs	ODEQ, WyEast RC&D, others	Ongoing		Ongoing	0-5 years	Moderate
Implement Agricultural Water Quality Management Plan	ODA, SWCD	Ongoing	Subbasin-wide	Ongoing	variable	High
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High
Acquire conservation easements or agreements, and important habitats when available.	NGO's	New	Subbasin-wide		Variable	High

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Wasco Co. SWCD, OWEB, Irrigators	Irrigation conveyance efficiency	Population-wide		Piping open ditches and other efficiency projects will decrease irrigation demand on streams. Program could be expanded to many additional irrigators. See State of Oregon programmatic review -- Appendix F.
ODEQ	TMDL Development	Population-wide		See State of Oregon programmatic review -- Appendix F.
ODEQ, Wasco Co. SWCD, ODFW, USFS	Temperature TMDL Implementation Monitoring	Fifteenmile Creek	USFS likely	Continuation of existing level of monitoring efforts could be expanded. Funding may not be sufficient. See State of Oregon programmatic review -- Appendix F.
ODEQ, ODA, Wasco SWCD, USFS	Sedimentation Monitoring (TMDL Development and Implementation)	Fifteenmile Creek	USFS likely	See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODEQ, WyEast RC&D	Toxics monitoring program doesn't actually exist yet	Population-wide		See State of Oregon programmatic review -- Appendix F.
ODA	Agricultural Water Quality Management Program	Private agricultural lands		See State of Oregon programmatic review -- Appendix F.
WyEast RC&D	IFPnet	Fifteenmile and Mill Creek	No	Program needs expansion to assist agriculture with reducing chemical demand.
Wasco Co. SWCD	No-till conversion, watershed restoration	Uplands population-wide		Program has proven effective at reducing erosion, but additional lands could be enrolled. See State of Oregon programmatic review -- Appendix F.
Wasco County SWCD/USDA FSA	CREP, CRP	Private riparian areas and qualified uplands throughout population		Both programs are effective at protecting riparian areas and uplands, however additional lands need to be enrolled. CRP program is near capacity for Wasco county. See State of Oregon programmatic review -- Appendix F. Some landowners reluctant to enter the federal programs.
CTWSRO	Watershed Restoration	Reservation lands	No	Various programs designed to improve riparian, stream, and upland conditions along tribal lands. Additional restoration and protection efforts are needed.
ODF	Oregon Forest Practices Act	Private and state forestlands in Fifteenmile, Eightmile, Ramsey , and Fivemile creeks		See State of Oregon programmatic review -- Appendix F.
ODFW	Fifteenmile Creek Fish Habitat Restoration Project	Private lands throughout population	No	Positive results where the program has been implemented, but funding and landowner cooperation limits the amount of available projects. In addit ion, limited legal guarantees that landowners remain in program.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
ODA's Agricultural Water Quality Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements.				

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and . unimpaired natural upland processes.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Continue to promote no-till and other seeding techniques that reduce erosion where site conditions are suitable	Fifteenmile Creek subbasin uplands	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	Over half of the agricultural land in the watershed has been converted to direct seed/no till, leaving 50,000-60,000 acres that could be converted (NPCC 2004).
Convert to perennial crops/vegetation		Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Develop Integrated Fruit Production (IFPnet) plans	Orchard lands throughout subbasin	Water quality, hydrology, sediment	Pollution	Abundance, productivity	All	
Upgrade or remove problem forest roads	Forest lands	Altered hydrology, sediment routing	Road network	Abundance, productivity	All	
Promote fuels management	Private and federal forest lands	Altered hydrology, sediment	Conversion of vegetative communities	Abundance, productivity	All	
Initiate upland improvement demonstration projects	Subbasin-wide	Altered hydrology, sediment routing	Upland land use practices	Abundance, productivity	All	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to minimize unnatural rates of erosion	Population-wide	Altered hydrology, sediment routing, water quality	Upland land use practices, erosion, loss of water storage capacity	Abundance, productivity	all	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Continue to promote no-till and other seeding techniques that reduce erosion where site conditions are suitable	SWCD	Existing program	Croplands, MaSAs	Ongoing (completed by 2012)	Reduce runoff, sediment supply, immediate increase in base flow	High
Convert to perennial crops/vegetation	SWCD	Develop new program	uplands	Ongoing	Reduce runoff, sediment supply immediately	High
Develop Integrated Fruit Production (IFPnet) plans	WyEast RC&D	Existing effort	Orchard lands throughout subbasin	Ongoing	Reduce chemical pollution immediately	High
Upgrade or remove problem forest roads	USFS, ODF, private forestland owners	Expansion of existing project	USFS lands	Long term	Variable depending on individual treatment (5-20 yrs)	Moderate

Promote fuels management	USFS, ODF, private forestland owners	Expansion of existing project	USFS lands and private forest lands	Long term	Variable depending on individual treatment (5-20 yrs)	Moderate
Initiate upland improvement demonstration projects	SWCD, ODA, OSU extension	Ongoing	Subbasin-wide	Ongoing	Variable lag time depending on action taken	Unknown
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to minimize unnatural rates of erosion	SWCD, USFS, ODA, CTWSRO, private landowners	Ongoing	High dispersal downstream	Intermediate	Up to 15 years	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Wasco County SWCD/USDA FSA	CREP, CRP	Private riparian areas and qualified uplands throughout population		Both programs are effective at protecting riparian areas and uplands, however additional lands need to be enrolled. CRP program is near capacity for Wasco County. Some landowners reluctant to enter the federal programs. See State of Oregon programmatic review -- Appendix F.
Wasco County SWCD	No-till conversion, watershed restoration	Uplands population-wide		Program has proven effective at reducing erosion, but additional lands could be enrolled. See State of Oregon programmatic review -- Appendix F.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands in Fifteenmile, Eightmile, Ramsey , and Fivemile Creek		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
USFS	Fifteenmile River keeper	USFS lands and non-forest lands under Wyden Amendment Authority	Likely	Positive results where the program has been implemented, but it could be expanded to more forest lands in the population, and become more available off forest lands. Contingent on year to year funding appropriations.
USFS	Northwest Forest Plan	All Mt. Hood National Forest lands	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
ODA	Agricultural Water Quality Management Program	Private agricultural lands		See State of Oregon programmatic review -- Appendix F.
OSU extension	Various	Private agricultural lands	Uncertain	Provide education and outreach information. Program could be expanded to be more effective.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize active watershed restoration for this population, and helps deploy limited active watershed restoration funding where it is most needed.

9.3.2 Habitat Strategies and Actions for Deschutes River Eastside Steelhead Population

Primary limiting factors: riparian condition, low flow, temperature, habitat diversity, and lack of fish passage.

Primary threats: grazing, roads, residences, and agriculture practices that simplify habitat; irrigation withdrawals; soil tilling, forest practices, dams and roads.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect the highest quality habitats through acquisition or conservation easements.	1-Bakeoven Cr. (mouth to Deep Cr) 1-Buck Hollow Cr (mouth to Macken Canyon) 1-Trout Cr. (Little Trout Cr. to headwaters) 2-Trout Cr. (Degner Cyn to Little Trout Cr.) 2-Deschutes R. (Harris Cr. to Buck Hollow Cr.) 2-Ward Cr. (mouth to Pole Cr.) 2-Deep Cr. (mouth to Cottonwood Cr)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	Overgrazing, channelization, stream bank armoring, agricultural practices, fire suppression,	Abundance, productivity	All	Protecting functioning floodplains and channels that are in balance with their ability to transport water and sediment is identified as one of the highest priorities in the Subbasin Plan. Wild and scenic protection for Deschutes in place.
Protect and conserve rare and unique functioning habitats	1-Seasonal tributaries 2-Trout Cr. (mouth to Willowdale)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	Abundance, productivity	All	Seasonal spawning tributaries provide habitat for unique life history trait that utilize seasonal habitats with age 0 migration into Deschutes.
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	1-Entire population	All factors	All	Abundance, productivity	All	To prevent habitat degradation BMPs and existing laws that protect habitat should be applied throughout the population.
Develop new and manage existing habitat Cooperative Agreements	Trout Cr. (mouth to headwaters)	Degraded floodplain, channel structure, riparian areas	All	Abundance, productivity	All	
Conduct outreach to resource users and managers	1-Entire population	All factors	All	All	All	Program efficiencies will be improved through increased knowledge and understanding of the importance of habitat conditions and land management practices.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Protect the highest quality habitats through acquisition or conservation easements.	CTWSRO, PGE, DRC, DBLT, NGOs, ODFW, SWCD, USDA FSA	Ongoing	High dispersal downstream	Immediate	Variable depending on habitat condition	High
Protect and conserve rare and unique functioning habitats	Land trusts, CTWSRO, ODFW, SWCD, NGOs, USFS, PGE, BLM	Ongoing		Immediate	Immediate halt to degradation	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	SWCD, USFS, private landowners, ODA, NRCS, CTWSRO, watershed councils, BLM, counties		All MaSAs	Long term	Degradation stop immediately habitat recovery 15-25 years depending on status	High
Adopt and manage Cooperative Agreements	ODFW	Ongoing	High dispersal downstream	Agreements are for 10-15 years	Immediate	High, although not in perpetuity
Conduct outreach to resource users and managers	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	**Program Name**	**Geographic Locations**	**Sufficient* (yes, likely, uncertain, no)**	**Sufficiency Rationale**
USFS and BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management Area designations PACFISH	USFS and BLM lands throughout population	Yes	Continual implementation of programs. See USFS/BLM Program Sufficiency Assessment -- Appendix E. Currently no additional opportunities to expand programs on BLM lands.
ODFW/BPA	Trout Creek Fish Habitat Restoration Project	Private lands in the Trout Creek subbasin	No	Additional lands can be enrolled into the program. Conservation agreements are for only 10-15 years length.
USDA FSA/SWCDs	CREP/CRP	Private agricultural lands throughout population	Likely	Additional lands can be enrolled, and programs are not permanent in duration. See State of Oregon programmatic review -- Appendix F.
CTWSRO	Integrated Resources Management Plan	Reservation lands	Yes	Adaptive 10-year management plans to guide future.
CTWSRO	Watershed Maintenance/ Riparian Fence Program	Reservation lands	No	Need to expand riparian fence network and maintenance of those fence lines.
ODA/SWCDs	Agricultural Water Quality Management Program	Private agricultural lands throughout population		See State of Oregon programmatic review -- Appendix F.
Local Government	County Planning and Zoning	Private lands throughout population	Uncertain	
PGE	Pelton Habitat Mitigation Fund	Upper population	Uncertain	Newly implemented program, results not yet available.
NGOs (Deschutes Basin Land Trust, Nature Conservancy, Deschutes River Conservancy, Oregon Water Trust etc.)	Lease or purchase of land or instream water rights	Private lands throughout population	No	Limited opportunities arise, but programs can be expanded when opportunities become available.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Watershed Councils	Various Watershed Councils	Population-wide	No	Programs can be expanded to included additional interested parties in watershed restoration and protection.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Existing forest plans include special management designations for riparian habitat conservation areas (RHCAs). Adding additional wilderness areas and wild and scenic river segments would require designation by Congress. The forest plans and BLM plans have been amended by PACFISH which generally requires 300-foot buffers on any fish bearing stream for tree removal with limited exceptions when conditions are met, as well as specific guidelines for livestock grazing and riparian vegetation use. See guidelines for Timber Management for specific rules governing the RHCA. Compliance with the 300-foot buffer for timber harvest operations has been very good.

FSA programs that protect riparian areas and upland watersheds include the CRP, which pays landowners not to farm highly erodible soils, and the CREP program, which pays landowners for setting riparian corridors side from grazing and farming. The long term effectiveness of both programs is limited by the relatively short duration of the contracts which ranges from 10 to 15 years.

ODA's Agricultural Water Quality Management Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategic Actions and Impacts on Limiting Factors, Threats, and Population

Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Replace or remove barriers blocking passage including dams, road culverts, irrigation structures, infiltration galleries	1-Mud Springs Cr. (at RR culvert in section 15, above Gateway)--Jefferson County 1-Hay Creek (new channel near mouth)--private 2-Antelope Cr. (mouth to headwaters)--not culverts 2-Trout Cr. (mouth to Clover)--not culverts	Impaired fish passage	Dams, culverts, instream structures	Abundance, spatial structure, productivity	Primarily adults and 0+juveniles	Adult passage is the first priority, juvenile passage is secondary. Cumulative effects of anthropogenic factors, increase temperatures and reduce streamflow impair juvenile passage on Trout Creek downstream from Forest boundary.
Maintain irrigation diversions and screens	1-Where diversions exist throughout population	Impaired fish passage	Irrigation diversions	Abundance, spatial structure, productivity	Primarily juveniles, but also adults at facilities with ladders.	All known diversion are maintained and generally meet screening criteria.
Provide screening at 100% of irrigation diversions	1-unscreened diversions (all known diversions screened, need comprehensive survey to identify additional needs)	Impaired fish passage	Irrigation diversions	Abundance, spatial structure, productivity	Juveniles	All known legal diversions screened. More surveys are needed in Trout Creek subbasin to identify add'l diversions.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove/replace barriers blocking passage including dams, road culverts and irrigation structures	CTWSRO, USFS, SWCDs, watershed councils, NRCS	Ongoing	Access between upstream and downstream habitats	Immediate	Immediate	High
Maintain irrigation diversions and screens	ODFW	Ongoing	Diversions subbasin-wide	Based on funding	Immediate	High
Provide screening at 100% of irrigation diversions	ODFW Fish Passage and Screening	Ongoing	Access between upstream and	Immediate as need is identified	Immediate	High

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.					
			downstream habitats		
Status of Existing Programs through which Actions are Implemented					
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale	
ODFW	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	Project has made significant improvement in overall fish habitat, needs to be expanded to other properties in subbasin. Recent large scale stream rehabilitation projects conducted on properties on Trout Creek have been successful at removing berms, restoring stream function, and creating additional habitat. Needs to be expanded in scope.	
Jefferson SWCD	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	This companion project to the ODFW Habitat Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin. Project has assisted in several infiltration gallery projects and other passage issues.	
ODFW	Fish Passage/Screening, State program and federal funded	Population-wide	Uncertain	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding. See State of Oregon programmatic review -- Appendix F.	
PGE/CTWSRO	Pelton Fish Passage Plan	Pelton complex	Uncertain	Program is currently being implemented; uncertain of success of downstream passage.	
CTWSRO/ODFW	Salmon and Steelhead Reintroduction Plan	Areas above Pelton complex	No	Adaptive plan over life of FERC license.	
ODOT	Culvert replacement or retrofit	Population-wide		See State of Oregon programmatic review -- Appendix F.	
CTWSRO	IRMP	Reservation Lands	Yes	Adaptive management plan guides implementation.	
CTWSRO/USFS	Culvert replacement	Population-wide	USFS likely with current program.	Needs expansion.	
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)					
A comprehensive fish screen inventory needs to be completed throughout the population. The Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) provides guidance that will help prioritize culvert replacements for this population.					

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	1-Trout Cr. (Little Trout Cr. To Clover Creek) 1-Trout Cr. (sections from mouth to Antelope Creek) 1-Antelope Cr. (mouth to headwaters)	Degraded floodplain, degraded riparian area, channel structure	Removal of interaction between river and floodplain, grazing, agricultural use, loss of	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Floodplains and channels that are in balance are essential for proper stream function. Bakeoven and Buck Hollow Creeks affected primarily from

Strategy 3. Maintain and restore floodplain connectivity and function.						
	1-Hay Cr. (mouth to headwaters) 2-Bakeoven Cr. (mouth to headwaters) 2-Buck Hollow Cr (mouth to headwaters)		beaver dams			livestock grazing.
Reconnect side channels and off-channel habitats to stream channels	1-Trout Cr. (Little Trout Cr. To Clover Creek) 1-Trout Cr. (sections from mouth to Antelope Creek) 1-Antelope Cr. (mouth to headwaters) 1-Hay Cr. (mouth to headwaters) 2-Bakeoven Cr. (mouth to headwaters) 2-Buck Hollow Cr (mouth to headwaters)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Off channel habitat important juvenile rearing habitat. Bakeoven and Buck Hollow Creeks effected primarily from livestock grazing.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	1-Throughout population	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity	All	As riparian areas recovery beaver recolonization occurs naturally.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain habitats.	CTWSRO, ODFW, watershed council, BLM, SWCDs, USFS, PGE, counties	Ongoing	High dispersal downstream from site	Long term	5-15 years	High
Reconnect side channels and off-channel habitats to stream channels.	CTWSRO, ODFW, watershed council, SWCD, USFS, BLM, PGE	Ongoing	High dispersal downstream from site	Long term	5-15 years	High
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	CTWSRO, ODFW, USFS, BLM	Ongoing	Subbasin-wide	Long term	Within 15 years	Moderate, high

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Sherman and Wasco SWCD, Landowners, Oregon State agencies.	Bakeoven and Buck Hollow Watershed Restoration Projects.	Bakeoven and Buck Hollow Creek	Likely	Project is underway in Bakeoven watershed and is planned over a 10-year period. Project is transitioning to effectiveness monitoring. See State of Oregon programmatic review -- Appendix F.
NRCS,SWCD, USDA FSA, Private Landowners	CREP/CRP	Private lands throughout population	SWCD likely Others uncertain	An effective program that could be expanded to more landowners. See State of Oregon programmatic review -- Appendix F.
BLM Prineville District	Various range and upland restoration projects.	BLM lands throughout population	Likely	Most lands currently meeting BLM Standards and Guidelines, continued monitoring is needed to ensure long-term compliance. Program implementation may need to expand in scope. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin.

Strategy 3. Maintain and restore floodplain connectivity and function.				
Jefferson SWCD	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	This companion project to the ODFW Habitat Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin.
PGE/CTWSRO	Relicensing of Pelton-Round Butte Complex	Throughout population	No	Habitat restoration and protection projects to mitigate effects of hydro projects. Addit ional opportunities exist.
CTWSRO	Various projects	Reservation lands	No	Improving riparian conditions, grazing remains problematic in some areas. Program needs expansion.
BLM, Oregon State Parks, CTWSRO	Wild and Scenic Rivers	Deschutes from mouth to Trout Creek		See State of Oregon and Federal agencies' programmatic reviews.
ODA/SWCD	Agricultural Water Quality Management Program	Private lands		See State of Oregon programmatic review -- Appendix F.
USFS	Stream Restoration Program (PACFISH)	Forest lands only when specifically identified that passive restoration is not working	Likely	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. Program implementation needs to expand in scope. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
CRP in uplands and riparian protection in the Buckhollow watershed have and will provide short term benefits, but instream physical habitat improvements may not accrue until the longer term. The future status of habitat benefits accruing from CRP enrollments could be unknown, since economic decisions by the landowners and government entities involved will influence the area under agreements. Planning and implementation of restoration and protection measures for Bakeoven Creek are similar to the Buck Hollow project, but began more recently. A draft watershed assessment has been completed and includes an action plan with a 10-year time frame (Clark and Lamson, 2005). The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form, includes berm and levee removal	1-Trout Cr. (Little Trout Cr. To Clover Creek) 1-Trout Cr. (sections from mouth to Antelope Cr.) 1-Antelope Cr. (mouth to headwaters) 1-Hay Cr. (mouth to headwaters) 2-Bakeoven Cr. (mouth to headwaters) 2-Buck Hollow Cr. (mouth to headwaters)	Degraded channel structure and complexity, floodplain, degraded riparian area, altered hydrology, degraded water quality, sediment routing	Grazing, agricultural practices, channelization, berms, roads, railroad bank armoring, floodplain, loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Channelization, berm construction, and bank armoring, following floods has isolated the stream from the floodplain in many areas. Large wood and other instream habitat complexity is lacking in the Buck Hollow watershed.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Increase role and abundance of wood and large organic debris in streambeds	1-Trout Cr. (Mouth to Board Hollow Cr.) 1-Antelope Cr. (mouth to headwaters)	Degraded channel structure and complexity, floodplain, degraded riparian area , altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Large woody debris in Deschutes River mainstem consists mostly from white alder trees downstream of hydro projects, currently little or no recruitment from upstream sources. Most problematic upstream of Warm Springs River.
Increase instream habitat through manual placement of structures		Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Considered an active form of restoration while habitat conditions are restored through more passive efforts
Stabilize streambanks with passive restoration processes	1-Trout Cr. (Little Trout Cr. To Clover Creek) 1-Trout Cr. (sections from mouth to Antelope Creek) 1-Antelope Cr. (mouth to headwaters) 1-Hay Cr. (mouth to headwaters) 2-Bakeoven Cr. (mouth to headwaters) 2-Buck Hollow Cr. (mouth to headwaters)	Degraded channel structure and complexity, floodplain connectivity, degraded riparian areas, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form, includes berm and levee removal	CTWSRO, ODFW, SWCD, USFS, BLM, watershed councils	Ongoing	High dispersal downstream	Long term	5-15 years	High
Increase role and abundance of wood and large organic debris in streambeds	ODFW, USFS, PGE, CTWSRO, watershed councils	Ongoing	Localized to treatment area	Long term	Immediate	High
Increase instream habitat through manual placement of structures	ODFW, USFS, CTWSRO	Ongoing	Limited application throughout population	Long term	Immediate	High
Stabilize streambanks	CTWSRO, ODFW, SWCD, watershed councils, USFS, BLM, ODA	Ongoing	High dispersal downstream	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Sherman and Wasco SWCD, Landowners, Oregon State agencies, BPA	Bakeoven and Buck Hollow Watershed Restoration Projects	Bakeoven and Buck Hollow Creeks		Effective project, but could be developed onto more private lands. See State of Oregon programmatic review -- Appendix F.
NRCS,SWCD, USDA FSA, Private Landowners	CREP/CRP	Riparian and upland areas throughout population	Uncertain	An effective program for both upland and riparian protection, but could be expanded to additional private lands. See State of Oregon programmatic review -- Appendix F.
BLM Prineville District	Various range and upland restoration projects.	BLM lands	Likely	Most lands currently meeting BLM Standards and

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.				
				Guidelines, continued monitoring is needed to unsure long-term compliance.
ODFW	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin.
Jefferson SWCD	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	This companion project to the ODFW Habitat Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin.
PGE/CTWSRO	Relicensing of Pelton-Round Butte Complex	Throughout population	No	Habitat restoration and protection projects to mitigate effects of hydro projects. Addit ional opportunities exist.
CTWSRO	Various projects	Reservation lands	No	Improving riparian conditions, grazing remains problematic in some areas, needs expansion.
BLM, Oregon State Parks, CTWSRO	Wild and Scenic Rivers	Deschutes from mouth to Trout Creek	Likely	See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODA/SWCD	Agricultural Water Quality Management Program	Throughout population		See State of Oregon programmatic review -- Appendix F.
USFS	Stream Restoration Program (PACFISH)	Forest lands only when specifically identified that passive restoration is not working	Likely	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. Needs to be expanded to more streams in Trout Creek Subbasin. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (UDSA-FS, 2005).
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
CRP in uplands and riparian protection have and will provide short term benefits, but instream physical habitat improvements may not accrue until the longer term. The upper third of Buck Hollow remains a restoration priority. The future status of habitat benefits accruing from CRP enrollments are unknown, since economic decisions by the landowners and government entities involved will influence the area under agreements. Planning and implementation of restoration and protection measures for Bakeoven Creek are similar to the Buck Hollow project but began more recently. Some riparian areas are still unbuffered through fences or grazing management plans. Where riparian buffers do exist, habitat complexity will develop over the longer term if buffers are maintained. Some benefits from trees will be slow to accrue because their size is relatively small, and only when larger age-classes are present, will the biological and physical results of large wood recruitment be realized. Recent large scale stream rehabilitation projects in the Trout Creek watershed have been successful at removing berms, restoring stream function, and creating additional habitat, however long-term monitoring is needed. Several landowners with sensitive key spawning and rearing habitats in the Upper Trout Creek may be willing to participate in conservation efforts. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian	1-Trout Cr. (Little Trout Cr. To Clover	Bank degradation, degraded riparian	Livestock grazing,	Abundance,	All	Riparian areas in the Bakeoven,

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
communities including vegetative planting	Creek) 1-Trout Cr. (sections from mouth to Antelope Creek) 1-Antelope Cr. (mouth to headwaters) 1-Hay Cr. (mouth to headwaters) 2-Bakeoven Cr. (mouth to headwaters) 2-Buck Hollow Cr. (mouth to headwaters) 2-Deschutes R. (Harris Cr. to Buck Hollow Cr.) 2-Deschutes R. (Eagle Cr. to Shitike Cr.)	communities, LWD recruitment, temperatures, flow, sediment routing	agricultural conversion, roads, bank armoring, residential development, loss of beaver dams	productivity		Buck Hollow and Trout Cr MaSAs have been reduced or damaged by grazing. Riparian canopy cover is relatively low. Streambank erosion and loss of riparian vegetation has led to wide shallow channels and width-to-depth ratios are greater than desirable throughout the watershed. Existing riparian vegetation contributes little to LWD. Loss of riparian function has led to increased sedimentation. Along Deschutes River, railroad armored banks limit riparian growth, campgrounds and heavy recreational use trample streamside vegetation, landowners have cleared vegetation around residences to improve river views and access.
Develop grazing strategies that promote riparian recovery	Limited opportunities may exist throughout the population	Bank degradation, degraded riparian communities, flow, sediment routing	Overgrazing	Abundance, productivity	All	
Eradicate invasive plant species from riparian areas	Where opportunities exist throughout the MaSA	Degraded riparian communities	Conversion of natural riparian vegetative communities	Abundance, productivity	All	
Install/maintain fencing to exclude livestock from riparian areas	1-Trout Cr. (Little Trout Cr. to Clover Cr.) 1-Trout Cr. (sections from mouth to Antelope Cr.) 1-Antelope Cr. (mouth to headwaters) 1-Hay Cr. (mouth to headwaters) 2-Bakeoven Cr. (mouth to headwaters) 2-Buck Hollow Cr. (mouth to headwaters) 2-Deschutes R. (Harris Cr. to Buck Hollow Cr.) 2-Deschutes R. (Eagle Cr. to Shitike Cr.)	Bank degradation, degraded riparian communities, flow, sediment routing	Overgrazing	Abundance, productivity	All	Cattle grazing along the mainstem Deschutes River., damages riparian vegetation and causes increases in erosion.
Install off-stream livestock watering	Limited opportunities may exist throughout the MaSA	Degraded riparian communities, sediment routing	Overgrazing	Abundance, productivity	All	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian communities including vegetative	CTWSRO, USFS, SWCDs, ODFW, watershed councils,	Ongoing	High dispersal downstream	Long term	5-15 years	High

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
planting	BLM, OWEB					
Develop grazing strategies that promote riparian recovery	CTWSRO, USFS, ODA, SWCDs, BLM	Ongoing	High dispersal downstream	Long term	5-15 years	High
Eradicate invasive plant species from riparian areas	CTWSRO, USFS, ODA, SWCDs, watershed councils, BLM	Ongoing		Immediate	5-15 years	
Install/maintain fencing to exclude livestock from riparian areas	SWCDs, NRCS, CTWSRO, ODA, SWCDs, ODFW, BLM	Ongoing	High dispersal downstream	Immediate	Riparian restoration (0-20 years); increased streamflow, stabilized hydrograph (0-10 yrs)	High
Install off-stream livestock watering	ODFW, CTWSRO, USFS, ODA, SWCD, BLM	Expansion of existing effort	Private lands	Ongoing	Riparian restoration (0-5 years)	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTWSRO	Watershed Maintenance	Reservation	No	Needs to be expanded and continued.
CTWSRO	IRMP	Reservation	No	Adaptive management plan.
BLM, Oregon State Parks, CTWSRO	Wild and Scenic Rivers	Deschutes from mouth to Trout Creek	Likely	See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	Project has made significant improvement in overall fish habitat, needs to be expanded to other properties in subbasin, needs expansion and additional funds.
Jefferson SWCD	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	This companion project to the ODFW Habitat Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin, and needs additional funds.
USFS	Stream Restoration Program (PACFISH)	Forest lands	Likely	Needs to be expanded to more streams in Trout Creek Subbasin. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.
NRCS,SWCD, USDA FSA, Private Landowners	CREP	Throughout population	Uncertain	An effective program for both riparian protection and restoration, but could be expanded to additional private lands.
ODA	Agricultural Water Quality Management Program	Throughout population		See State of Oregon programmatic review -- Appendix F.
Watershed Councils/OWEB	Various restoration projects	Throughout population	Uncertain	Effective program for developing restoration/protection projects and supplying outreach information on resource management. Participation could be expanded.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Bakeoven Project is beginning and is planned over a 10-year period. Some riparian areas are still unbuffered through fences or grazing management plans. Habitat complexity will develop over the longer term if existing buffers are maintained. Some benefits from trees will be slow because the trees are small. Only when larger age-classes exist will biological and physical results of large wood recruitment be realized.

Riparian improvements in Trout Creek watershed have improved water quality, but additional protection is needed throughout the subbasin.

Public land managers have implemented PACFISH standards for protection and restoration of USFS and BLM lands. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funding where it is most needed.

The USFS requires fence maintenance for all grazing allotments. New fencing may be part of adjustments to existing grazing strategies by the USFS/BLM to promote riparian recovery.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	1-Trout Cr. (mouth to Clover Cr.) 1-Antelope Cr. (mouth to headwaters) 2-Hay Cr. (mouth to headwaters)	Altered hydrology, low flows, high temperatures	Water withdrawals, land conversion on uplands, road network	Abundance, productivity	Primarily fry and summer parr	Consumptive use of flows in Trout Creek exceeds the natural streamflow. Streamflow below Amity Creek averages < 1cfs during the summer (WPN 2002). Flows in Trout Cr. below diversions in the Ashwood and Willowdale areas frequently become intermittent from mid-summer to late fall. Trout Cr. from Hay Creek to Little Trout Creek is listed as priority in EDT.
Improve irrigation conveyance and efficiency	1-Trout Cr. Forest boundary downstream	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Primarily fry and summer parr	Conversion of flood to sprinkler irrigation, irrigation efficiency improvement, and piping would increase flows.
Lease or purchase water rights and convert to instream	1-Trout Cr. subbasin (where available) 2-Buck Hollow Creek	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	One surface water right exists (0.57 cfs) in a lower reach of Buck Hollow.
Monitor/regulate water withdrawals	1-Trout Cr. MaSA	low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	Most water withdrawals are not monitored for compliance.
Water retention structures	1-Uplands in Bakeoven and Buck Hollow Creeks	Altered hydrology, low flows	Degradation on uplands	Abundance, productivity	Primarily fry and summer parr	
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Altered hydrology, low flows, high temperatures, impaired natural functions and processes on uplands, floodplains, riparian areas	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Primarily fry and summer parr	Flow fluctuations are now larger than they were historically. High flows have scoured out channels reducing habitat diversity. Reduct ion of native upland vegetation has reduced its ability to retain and slowly release runoff. Lack of water in the lower reaches and Bakeoven and Deep creeks impedes upstream and downstream fish passage.
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Implement agricultural water conservation measures	SWCD, CTWSRO, USBOR, irrigation districts, landowners	Expands existing program, new projects	Croplands, MaSAs	Based on funding	Immediate increase in Streamflow; habitat diversity, floodplain connection (0-5 yrs)	High
Improve irrigation conveyance and efficiency	SWCD, USFS, OWRD, CTWSRO, OWEB, landowners	Expands existing program, proposes new projects	High dispersal downstream	Ongoing	Increased streamflow (0-5 years)	High
Lease or purchase water rights and convert to instream	OWRD, Oregon Water Trust, PGE, DRC, others	Ongoing	Point of diversion to mouth of Deschutes	Long term	Immediate increase in instream flow	High
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion to mouth of Deschutes	Long term		High
Water retention structures	SWCDs	Ongoing	Uplands	Intermediate	0-10 years	Moderate
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD, USFS, OWRD, OWEB, ODFW, CTWSRO, landowners	Ongoing	Subbasin-wide	Intermediate	Up to 15 years	High
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	**Program Name**	**Geographic Locations**	**Sufficient* (yes, likely, uncertain, no)**	**Sufficiency Rationale**
Sherman and Wasco SWCD, Property Owners, CTWSRO, and Oregon State agencies	Bakeoven Watershed Project	Bakeoven Creek		Effective programs that will take time before results are available. Program could be expanded to additional landowners. See State of Oregon programmatic review -- Appendix F.
ODFW	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin. Recent large scale stream rehabilitation projects conducted on properties on Trout Creek have been successful at removing berms, restoring stream function, and creating additional habitat. Project needs expansion.
Jefferson SWCD	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	This companion project to the ODFW Habitat Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin. Project has

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.				
				assisted in several infiltration gallery projects and other passage issues. Project needs expansion.
BLM	Various projects related to rangeland improvements in uplands	BLM lands	Uncertain	Effective programs. Long-term monitoring of effectiveness is needed. See USFS/BLM Program Sufficiency Assessment--Appendix E.
NRCS,SWCD, FSA, Private Landowners	CRP, CREP	Riparian and upland areas within population	No	An effective program for both upland and riparian protection, but could be expanded to additional private lands.
FSA, OWEB	Lease instream water rights	Specific locations determined by opportunities		Both OWEB and FSA have partnered with landowners to return water instream. Additional opportunities should be pursued.
OWRD	Stream Flow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Specific locations determined by opportunities		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust	Lease water rights and return instream	Specific locations determined by opportunities	Uncertain	Program works well, could be expanded with more willing landowners. Need assurance that instream leases remain instream.
Jefferson SWCD, NRCS	Various irrigation efficiency improvements, CRP, CREP	Specific locations determined by opportunities	Uncertain	Needs expansion.
ODA/SWCD	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The Deschutes subbasin plan's (NPCC 2004) inventory notes that Buck Hollow "runs clean", intermittent tributaries have become perennial. Opportunities may exist to increase summer flows, reduce temperature, and decrease sedimentation through water development (Lower Deschutes River Management Plan). In 2001, 1 to 1.5 cfs from a headwater well in Buck Hollow Cr. was used to supplement flow to protect fish from the drought (BPA #200105400). The Deschutes River subbasin has 578 miles of stream protected by instream water rights. Voluntary flow restoration restored 13.4 cfs in 2006, of which 3.2 cfs was permanent.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Manage irrigation return flow to reduce extreme stream temperatures	1-Trout Cr. (mouth to Clover Cr.) 1-Antelope Cr. (mouth to headwaters) 2-Hay Cr. (mouth to headwaters)	Altered stream temperatures, degraded water quality	Water withdrawals	Abundance, productivity	Fry dispersal and rearing	Reaches of Buck Hollow, Bakeoven and Trout creeks are included on the 303(d) list for exceeding temperature and sediment limits. Temperatures in the systems typically exceed criteria for salmonid rearing during summer months. Several reaches are also listed

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
						because of sediment concerns.
Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	1-Trout Cr. (mouth to sagebrush)	Depleted oxygen		Abundance, productivity	Fry dispersal and rearing	Warm temperatures and potential pollutants reduce the dissolved oxygen capacity of the water.
Implement Agricultural Water Quality Management Program	Agricultural lands throughout population	Degraded upland processes, altered hydrology, water quality, altered sediment routing	Land conversion and agricultural practices	Abundance, productivity	Fry dispersal and rearing	
Continue TMDL monitoring	Population-wide	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Manage irrigation return flow to reduce extreme stream temperatures	SWCDs	Ongoing	High dispersal downstream	Less than 5 years	Immediate	High
Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	ODA, SWCD, ODEQ	Ongoing	Localized and downstream	Long term	Long term	Moderate
Implement Agricultural Water Quality Management Plan	ODA, SWCD		Subbasin-wide	Ongoing	Variable	High
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD	Ongoing	Subbasin-wide, high dispersal downstream	Intermediate	Up to 15 years	High
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Oregon Water Trust, NGOs	Lease or purchase instream water rights.	Trout Creek MaSA	No	Program has been effective, difficult to obtain senior water rights and keep water instream. Program could be expanded.
ODFW	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	Project has made significant improvement is overall fish habitat, needs to be expanded to other properties in subbasin. Recent large scale stream rehabilitation projects conducted on properties on Trout Creek have been successful at removing berms, restoring stream function, and creating additional habitat. Project needs expansion.
Wasco SWCD, Property Owners, CTWSRO, and Oregon State agencies, BPA	Bakeoven/Buck Hollow Watershed Project	Bakeoven Cr. and Buck Hollow Cr.	Uncertain	Effective programs that will take time before results are available. Program could be expanded to additional landowners.
BLM	Various projects related to rangeland improvements in uplands	BLM lands	Likely	Effective programs. See USFS/BLM Program Sufficiency Assessment -- Appendix E.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.				
Jefferson SWCD	Trout Creek Fish Habitat Restoration Project (BPA)	Trout Creek MaSA	No	This companion project to the ODFW Habitat Project has made significant improvement in overall fish habitat, needs to be expanded to other properties in subbasin. Project has assisted in several infiltration gallery projects and other passage issues. Needs expansion.
FSA, NRCS,SWCD, Private Landowners	CRP, CREP	Riparian and upland areas throughout population	Uncertain	An effective program for both upland and riparian protection, but could be expanded to additional private lands. See State of Oregon programmatic review -- Appendix F for SWCD.
ODA/SWCD	Agricultural Water Quality Management Program	Throughout population		See State of Oregon programmatic review -- Appendix F.
USFS	Stream Restoration Program (PACFISH)	USFS lands	Uncertain	Needs expansion. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funding for riparian planting where it is most needed.				

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Continue to promote no-till and other seeding techniques that reduce erosion where site conditions are suitable	1-Buck Hollow Cr. uplands 1-Bakeoven Cr. uplands	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Convert to perennial crops/vegetation (CRP)	1-Buck Hollow Cr. uplands 1-Bakeoven Cr. uplands	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Remove junipers	1-Trout Cr. uplands 2-Bakeoven Cr. uplands 2-Buck Hollow Cr. uplands	Altered hydrology	Loss of water storage capacity	Abundance, productivity	All	
Restore native upland plants and remove noxious weeds	1-Buck Hollow Cr. MaSAs 1-Bakeoven Cr. MaSAs 2-Trout Cr. MaSAs	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Upgrade or remove problem forest roads	1-Trout Cr. Private Forest Lands 2-Trout Cr. USFS Forest Lands	Altered hydrology, sediment routing	Road network	Abundance, productivity	All	
Promote reforestation and fuels management	1-Trout Cr. Private Forest Lands 2-Trout Cr. USFS Forest Lands	Altered hydrology, sediment	Conversion of vegetative communities	Abundance, productivity	All	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Employ BMPs to minimize unnatural rates of erosion	Population-wide	Altered hydrology, sediment routing, water quality	Upland land use practices, erosion, loss of water storage capacity	Abundance, productivity	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Continue to promote no-till and other seeding techniques which reduce erosion where site conditions are suitable	SWCD	Existing program	Croplands, MaSAs	Ongoing	Reduce runoff, sediment supply, immediate increase in base flow	High
Convert to perennial crops/vegetation (CPR)	NRCS, SWCDs	Ongoing	Croplands	Immediate	0-10 years	High
Remove junipers	SWCDs, NRCS	Ongoing	Uplands	Immediate	0-20 years	High
Restore native upland plants	USFS, BLM, NRCS, SWCDs, watershed councils, CTWSRO, BIA	Ongoing	High dispersal downstream	Juniper control can be quick, other actions such as control of invasive plants may take 20 years or more	0-20 years	High
Upgrade or remove problem forest roads	CTWSRO, USFS, ODOT, ODF	Ongoing	High dispersal downstream	Long term	Immediate for sediment, other parameters 5-15 yrs	High
Promote reforestation and fuels management	CTWSRO, USFS, watershed councils, SWCDs, counties	Ongoing	Forestlands	Long term	0-10 yrs	High
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to minimize unnatural rates of erosion	SWCD, USFS, ODA, ODF, BLM, CTWSRO, watershed councils, NRCS, private landowners	Ongoing	High dispersal downstream	Intermediate	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS,SWCD, Private Landowners	CRP, CREP, Environmental Quality Incentive Program (EQUIP)	Private upland and riparian lands	Uncertain	An effective program for both upland and riparian protection, but could be expanded to additional private lands. Continued implementation of program dependent on funding. See State of Oregon programmatic review -- Appendix F for SWCD.
SWCDs	Voluntary Watershed Restoration	Private agricultural lands		Dependent on funding, and landowner interest. See State of Oregon programmatic review -- Appendix F.
BLM	Various projects related to rangeland improvements in uplands.	BLM lands	Likely	Effective programs that could be expanded to additional lands.
CTWSRO	IRMP	Reservation Lands	Yes	Adaptive plan could be expanded.
USFS	Stream Restoration Program (PACFISH), Vegetation Management Programs, Range Management Programs	USFS forest lands	Uncertain	Effectiveness of program unproven. May need expanded monitoring. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.				
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Many benefits to steelhead have accrued through changes in upland and riparian management plans since the 1987 Farm Bill. CRP in uplands and riparian protection have and will provide short term benefits, but instream physical habitat improvements may not accrue until the longer term. The upper third of Bakeoven and Buck Hollow creeks remain restoration priorities. The future status of habitat benefits accruing from CRP and CREP enrollments could be unknown, since economic decisions by the landowners and government entities involved will influence the area under agreements. No areas within the Bakeoven or Buck Hollow watersheds are in a "protected" status. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize active watershed restoration for this population, and helps deploy limited active watershed restoration funding where it is most needed.				

9.3.3 Habitat Strategies and Actions for Deschutes River Westside Steelhead Population

Primary limiting factors: degraded floodplain connectivity and function, altered sediment routing, water temperatures, degraded channel structure and complexity, degraded riparian area, altered hydrology, and degraded fish passage – particularly lack of passage over Pelton-Round Butte Complex.

Primary threats: road networks (including Hwy 26 Beaver Creek, USFS roads, Tribal road networks), logging practices, grazing practices, removal of overstory trees and bank vegetation from the riparian corridor, stream channelization, water withdrawal (Whychus Creek).

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect the highest quality habitats through acquisition or conservation easements	Spawning areas in mainstem Deschutes River below Pelton-Round Butte Complex	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	All	All	Protecting high quality habitats is the most cost effective way to ensure fish have good quality habitat. Land acquisitions, easements, and cooperative agreements may facilitate the implementation of active restoration projects.
Protect and conserve rare and unique functioning habitats	Throughout population	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	All	All	
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	MaSAs in Warm Springs River subbasin, MaSA in Shitike Creek, potential MaSAs in Whychus Creek and Metolius River	All	All	All	All	
Adopt and manage Cooperative Agreements	Private and public lands	Degraded floodplain, channel structure, riparian areas	All	All	All	
Special management designations on public lands	Public lands	All	All	All	All	
Conduct outreach to resource users and managers	1-Entire population	All	All	All	All	Program efficiencies will be improved through increased knowledge and understanding of the importance of habitat practices.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements.	CTWSRO, PGE, DRC, DBLT, NGOs, ODFW, SWCD, USDA FSA	Ongoing	High dispersal downstream	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	Immediate halt to degradation--recovery long term	High
Protect and conserve rare and unique functioning habitats.	Land trusts, CTWSRO, ODFW, SWCD, NGOs, USFS	Ongoing	Population-wide	Immediate	Immediate halt to degradation--recovery long term	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	SWCD, USFS, private landowners, ODA, CTWSRO	Ongoing	Population-wide	Long term	5-15 years	High
Adopt and manage Cooperative Agreements.	CTWSRO	Ongoing	High dispersal downstream	Agreements are for 10-15 years	Immediate	High, although not in perpetuity
Special management designations on public lands.	USFS, BLM	Ongoing	High dispersal downstream	Complete; potentially subject to change in Forest Plan revisions	Immediate in some cases, long term for recovery of habitat	High, although subject to change from Forest Plan or management plan revision
Conduct outreach to resource users and managers.	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Varies depending on location and issues	Unknown, depends upon action taken as a result of being more informed

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS and BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management Area designations, PACFISH	Three Sisters Wilderness; Mt Jefferson Wilderness; Metolius River; Whychus Creek	Uncertain	See USFS/BLM Program Sufficiency Assessment—Appendix E. Addit ional areas could be considered for Wilderness or similar management designations. PACFISH applies to all BLM and FS management programs and lands in the Mid-C.
ODFW	Cooperative Agreements	Spring Creek Deschutes River	No	The agreements are for only 10-15 years and should be extended.
USDA FSA	CREP	Seekseequa Creek	Uncertain	The agreements are for only 10-15 years and should be extended.
CTWSRO	Integrated Resources Management Plan III	Warm Springs 5th field HUCs (8) Shitike Cr 5th Field HUC	Yes	Managed under 10-year adaptive management plan.
CTWSRO	Watershed Maintenance/ Riparian Fence Program	Warm Springs River RM 0.0 – 3.5 Warm Springs River RM 27.5 - 30 Lower Deschutes River RM 73-84 Beaver Creek RM 0.25-3.5	No	Need to continue to expand riparian fence network and maintenance of those fence lines.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
		Beaver Creek RM 14-18 Bager Creek RM 0.5-2.5 Skookum Creek RM 0-1.0 Mill Cr. (RM 5.5 to RM 6)		
ODA	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.
Local Government	City and County Planning and Zoning	Whychus Creek floodplain zoning - In Progress	Yes	Could be expanded.
NGOs	Deschutes Basin Land Trust, Nature Conservancy, Deschutes River Conservancy, etc.	Land purchase on Lake Creek Land purchase on Whychus Creek	Uncertain	Need to increase minimum flows by another 10 cfs through the city of Sisters.
SWCD	CREP	Population-wide		Agreements are for only 10-15 years and should be extended.
Watershed Councils	Upper Deschutes River Watershed Council	Upper Deschutes		
Deschutes River Conservancy or other entity	Lease or purchase instream water rights	Whychus Creek 20cfs secured instream flow	Yes	Important to secure water rights to guarantee instream flow, could be expanded.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The majoriy of the Deschutes Westside steelhead spawning areas occurs within the CTWSRO boundaries. The CTWSRO has developed and implemented the Integrated Resources Management Plan on Reservation lands. Adding additional wilderness areas and wild and scenic river segments would require designation by Congress. Exist ing forest plans include special management designations for RHCAs. The forest plans and BLM plans have been amended by PACFISH, which requires 300-foot buffers on any fish bearing stream for tree removal, as well as specific guidelines for livestock grazing and riparian vegetation use. Compliance with the 300-foot buffer for timber harvest operations has been very goods. FSA programs that protect riparian areas and upland watersheds include the CRP, which pays landowners not to farm highly erodible soils, and the CREP program, which pays landowners for setting riparian corridors aside from grazing and farming. The long-term effectiveness of both programs is limited by the relatively short duration of the contracts which ranges from 10 to 15 years. ODA's Agricultural Water Quality Management Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements.				

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore passage at Pelton-Round Butte Complex	1- Deschutes R. (RM 100, Pelton-Round Butte)	Blocked fish passage, altered flows, sediment routing, degraded channel structure and complexity	Dam	Spatial structure, productivity, abundance	All	Dam construction in 1964 and failure of downstream fish passage led to extirpated steelhead populations above the complex. Currently efforts underway to restore passage as part of FERC process.
Replace barriers blocking passage including dams, road culverts and irrigation structures	1- Warm Springs R. 1- Beaver Cr. 1- Shitike Cr. There are six culverts that need replacement on CTWSRO lands.	Impaired fish passage	Dams, culverts, instream structures	Spatial structure, productivity	Primarily adults and 0+juveniles	Irrigation diversions occur primarily above the project. There has been a culvert inventory conducted on the CTWS Reservation identifying problem areas.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Provide screening at 100% of irrigation diversions	1-Whychus Cr. – Three Sisters irrigation diversion	Impaired fish passage	Irrigation diversions	Spatial structure, productivity	Primarily smolts and 0+juveniles	
Replace screens that do not meet criteria	1-Whychus Cr.	Impaired fish passage	Irrigation diversions	Spatial structure, productivity	Primarily smolts and 0+juveniles	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore passage at Pelton-Round Butte Complex	PGE, CTWSRO, ODFW,	Expansion of existing project	Historical steelhead range	Unknown	Immediate increase in instream flow	High
Replace barriers blocking passage including dams, road culverts and irrigation structures	CTWSRO, USFS, SWCDs, watershed councils	Ongoing	Provide access to upstream habitat	Ongoing, replacing all culverts expected to take 20 years	Immediate	High
Provide screening at 100% of irrigation diversions	ODFW	Ongoing	At point of diversion	Number of screens needs to be determined	Immediate	High
Replace screens that do not meet criteria	ODFW	Ongoing	At point of diversion	Number of screens needs to be determined	Immediate	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name		Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	Fish Passage/Screening	Whychus Creek – Three Sisters irrigation diversion Whychus Creek – Sokol Diversion Whychus Creek – Baker Ranch Irrigation Pond	No	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding. Rating of no given because adequate funds to quickly complete screening not available.
PGE, CTWSRO	Pelton Fish Passage Plan	Whychus Creek Deschutes River Metolius River	Uncertain	Program not implemented. 50-year timeframe. Considerable uncertainty regarding smolt passage survival.
CTWSRO, ODFW	Salmon and Steelhead Reintroduction Plan	Whychus Creek Metolius River	Uncertain	Adaptive plan over life of FERC license, considerable uncertainty regarding future success.
ODOT	Culvert replacement or retrofit		Uncertain	See State of Oregon programmatic review -- Appendix F.
CTWSRO	IRMP	Warm Springs River	Yes	Adaptive management plan could use expansion.
CTWSRO, USFS	Culvert replacement	Metolius River 5th field HUC Oak Creek Rm 0.01	USFS Yes	Timeframe to complete installation uncertain and program could use expansion. Only two major culverts left to be replaced in the Metolius—USFS has replaced 8 culverts in last 4 years.
Upper Deschutes Watershed Council	Various passage projects	Lake Creek Whychus Creek	Yes	Projects currently on Whychus Creek and Lake Creek could be expanded to other areas.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The major issue for this strategy is passage above the Pelton-Round Butte Complex. A new FERC license was issued in June of 2005. A main component of the license is the reintroduction of salmon and steelhead above the PRB. New facilities, evaluation, modifications will need to be implemented. Juvenile out plants, downstream fish passage efficiencies and timelines have been defined in the Salmon and Steelhead Reintroduction and Conservation Plan in draft written by ODFW and CTWS.

The Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) provides guidance that will help prioritize culvert replacements for this population.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	1- Deschutes R. (Eagle Cr to Shitike Cr) 1- Deschutes R. (Trout Cr. to PRB) 1- Warm Springs R. (mouth to RM 31) 1- Shitike Cr. (mouth to RM 5) 1- Beaver Cr. (mouth to RM 26) 1- Mill Cr. (RM 5 to RM 6.5) 2- Quartz Cr. (Mouth to RM 5) 2- Coyote Cr. (Mouth to RM 11) 1- Potential MaSAs in Whychus Cr. 2- Potential MaSAs in Metolius	Degraded floodplain, degraded riparian area, channel structure	Removal of interaction between river and floodplain, grazing, agricultural use, loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Floodplains and channels that are in balance are essential for proper stream function.
Reconnect side channels and off-channel habitats to stream channels	1- Deschutes R. (Eagle Cr to Shitike Cr) 1- Deschutes R. (Trout Cr. to PRB) 1- Warm Springs R. (mouth to RM 31) 1- Shitike Cr. (mouth to RM 5) 1- Beaver Cr. (mouth to RM 26) 2- Quartz Cr. (Mouth to RM 5) 2 - Coyote Cr. (Mouth to RM 11) 1- MaSAs in Whychus Cr. 2- Potential MaSAs in Metolius	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	In 1995, about 68% of all steelhead spawning in the mainstem Deschutes River from the Reregulating Dam to Trout Creek occurred in side channels between islands and channel margins, despite the fact that such channels comprise less than 10% of the channel length in the reach (Zimmerman and Ratliff 2003).
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	1- Beaver Cr. (RM 11 to RM 22)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity	All	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain habitats	CTWSRO, ODFW, watershed council, SWCD, USFS	Ongoing	Improved connectivity with channel will be localized; improved water table will increase streamflow and lower water temperatures downstream.	Long term	5-15 years	Moderate
Reconnect side channels and off-channel habitats to stream channels	CTWSRO, ODFW, watershed council, SWCD, USFS	Ongoing	Improved connectivity with channel will be localized; improved water table will increase streamflow and lower water temperatures downstream.	Long term	5-15 years	Moderate
Promote the maintenance and creation of beaver dams to restore the role in natural	CTWSRO, ODFW, USFS	Ongoing	Subbasin-wide	Long term	Within 5 years	Moderate

Strategy 3. Maintain and restore floodplain connectivity and function.						
ecological processes.						
Status of Existing Programs through which Actions are Implemented						
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale		
USFS, BLM, Grasslands	Stream enhancement program (PACFISH/NWFP)	Metolius River 5th field HUCs Whychus Creek 5th Field HUCs. Only when specifically identified that passive restoration is not working.	Yes	The USFS/BLM preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. Additional opportunities are limited, projects may arise. See USFS/BLM Sufficiency Assessment—Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).		
Watershed Councils	Watershed restoration	Whychus Creek RM 16.5	Uncertain	Only if specific needs cannot be addressed by passive restoration techniques.		
Soil and Water Conservation Districts	Watershed restoration	Population-wide		Only if specific needs cannot be addressed by passive restoration techniques.		
CTWSRO	IRMP	Warm Springs 5th field HUCs (8) Shitike Creek 5th Field HUC	Yes	Adaptive management plan, program could be expanded. See State of Oregon programmatic review -- Appendix F.		
ODA	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.		
NRCS, SWCD, private landowners	CREP	Beaver Creek (RM 0.25 to RM 3.5 and RM 14 to RM 18) Warm Springs River (RM 0 to RM 3.5 and RM 27.5 to RM 30)	Yes	Could be expanded.		
Upper Deschutes Watershed Council	Various restoration projects	Upper Deschutes subbasin	Uncertain	Program needs additional resources to expand.		
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)						
The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.						

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	1- Deschutes R. (Eagle Cr to Shitike Cr) 1- Deschutes R. ((Trout Cr. to PBR) 1- Warm Springs R. (mouth to RM 31) 1- Shitike Cr. (mouth to RM 5) 1- Beaver Cr. (RM 0.25 to RM 4, RM 14 to RM 15, and RM 18 to RM 26) 2 - Quartz Cr. (Mouth to RM 5)	Degraded channel structure and complexity, floodplain, degraded riparian area	Removal of interaction between river and floodplain, grazing, agricultural use, loss of beaver	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Habitat complexity has been reduced in Shitike Creek and Warm Springs River by channel simplification and land use practices, resulting in flashy flows that have scoured the channel.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
	2 - Coyote Cr. (Mouth to RM 11) 1- MaSAs in Whychus Cr. 2- MaSAs in Metolius 2- Mill Cr. (RM 5 to RM 7.5)		dams			
Increase role and abundance of wood and large organic debris in streambeds	1- Deschutes R. (Eagle Cr to Shitike Cr) 1- Deschutes R. (Trout Cr. to PBR) 1- Metolius R. 1- Warm Springs R. (mouth to RM 37 and RM 41 to RM 42) 1- Shitike Cr. (mouth to RM 5) 1- Beaver Cr. (RM 14 to RM 15 and RM 18 to RM 26) 2- Quartz Cr. 2- Coyote Cr. 1- MaSA in Shitike Cr. 1- MaSAs in Whychus Cr.	Degraded channel structure and complexity, floodplain, degraded riparian area , altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Removal of large wood (Metolius River) and channelizing streams have increased water velocities and reduced the ability of the stream to hold water for gradual release.
Increase instream habitat through manual placement of structures	2- Metolius R. 1- Shitike Cr. RM 0-5 1- Quartz Cr. RM 1-RM 2 1- Whychus Cr. RM 0.0-RM 32	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	large wood removal	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Considered an active form of restoration while habitat conditions are restored through more passive efforts.
Stabilize streambanks	1- Deschutes R. (Eagle Cr to Shitike Cr) 1- Deschutes R. (spawning areas below PRB) 1- Warm Springs R. (mouth to RM 31) 1- Shitike Cr. (mouth to RM 5) 1- Beaver Cr. (mouth to RM 26) 2- Quartz Cr. (mouth to headwaters) 2- Coyote Cr. (mouth to headwaters) 1- Potential MaSAs in Whychus Cr. 2- Potential MaSAs in Metolius	Degraded channel structure and complexity, floodplain connectivity, degraded riparian areas, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	CTWSRO, ODFW, SWCD, USFS, watershed councils	Ongoing	High dispersal downstream	Long term	5-15 years	High
Increase role and abundance of wood and large organic debris in streambeds	ODFW, USFS, PGE, CTWSRO, watershed councils	Ongoing	Treated area	Long term	Immediate	Moderate
Increase instream habitat through manual placement of structures	ODFW, USFS, CTWSRO	Ongoing	Treated area	Long term	Immediate	Moderate
Stabilize streambanks	CTWSRO, ODFW, SWCD, watershed councils, USFS, ODA	Ongoing	High dispersal downstream	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
PGE, CTWSRO	Lower Deschutes Gravel Study	Lower Deschutes	Yes	Possibly, based upon study results.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.				
PGE, CTWSRO	Large Wood Management Plan	Lower Deschutes	Yes	Adapt as program is implemented, program needs expansion.
USFS	Stream enhancement program (PACFISH)	Population-wide, only when specifically identified that passive restoration is not working	Yes	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. Programs generally effective. See USFS/BLM Sufficiency Assessment—Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
Watershed Councils	Watershed restoration	Population-wide	Uncertain	Only if specific needs cannot be addressed by passive restoration techniques.
SWCDs	Watershed restoration	Population-wide		Only if specific needs cannot be addressed by passive restoration techniques. See State of Oregon programmatic review -- Appendix F.
CTWSRO	IRMP	Reservation	Yes	Adaptive management plan, program could be expanded.
ODA	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.
NRCS, SWCD, private landowners	CREP	Population-wide	Likely	Could be expanded
Upper Deschutes Watershed Council	Various restoration projects	Upper Deschutes subbasin	Uncertain	Could be expanded.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Large wood placement in the lower Deschutes, gravel augmentation studies and evaluation will be conducted by PRBC licensees. The area of study and implementation will occur between the Reregulating Dam and Shitike Creek. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian communities	1- Deschutes R. (Eagle Cr. to Shitike Cr.) 1- Deschutes R. (Trout Cr. to PBR) 2 - Metolius R. 1- Warm Springs R. (mouth to RM 31., Ka-Nee-Ta resort area) 1- Shitike Cr. (mouth to RM 5, Community of Warm Springs, near Hwy 26) 1 - Beaver Cr. (mouth to RM 26) 2- Quartz Cr. (mouth to RM 5) 2 - Coyote Cr. (mouth to RM 11) 1- Potential MaSAs in Whychus Cr. 2- Mill Cr. (RM 5 to RM 6.5)	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing, noxious Weeds	Livestock grazing, agricultural conversion, roads, bank armoring, residential development, loss of beaver dams, noxious weeds	Abundance, productivity	All	Many stream systems have experienced a loss of riparian vegetation. Roads are located in many riparian areas within the subbasin (NPCC 2004b).

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Develop grazing strategies that promote riparian recovery	1- Whychus Cr.- RM 4 to RM16 2- Seekseequa Cr. 5th field HUC 1- Warm Springs R. 5th field HUCs 1- Shitike Creek 5th field HUC 2- Lower Deschutes River RM 74 to RM 100	Bank degradation, degraded riparian communities, flow, sediment routing	Overgrazing	Abundance, productivity	All	Significant opportunity to improve grazing strategies.
Eradicate invasive plant species from riparian areas	Lower Warm Springs River 5th field HUC Mill Creek 6th Field HUC Shitike Creek 5th field HUC Deschutes River RM 87 to Rm 100 Beaver Creek 5th field HUC	Degraded riparian communities	Conversion of natural riparian vegetative communities	Abundance, productivity	All	
Install fencing to exclude livestock from riparian areas	Warm Springs River RM 0.0 – 3.5 Warm Springs River RM 27.5 - 30 Lower Deschutes River RM 73-84 Beaver Creek RM 0.25-3.5 Beaver Creek RM 14-18 Badger Creek RM 0.5-2.5 Skookum Creek RM 0-1.0	Bank degradation, degraded riparian communities, flow, sediment routing	Overgrazing	Abundance, productivity	All	Specific locations will benefit significantly from livestock exclusion.
Install off-stream livestock watering	Badger Creek (RM 2.2) Warm Springs River (RM 28)	Degraded riparian communities, sediment routing	Overgrazing	Abundance, productivity	All	Off-channel water will reduce impacts in channel.
Plant riparian vegetation where appropriate	Beaver Creek Warm Springs River (mouth to Schoolie Creek, Ka-Nee-Ta resort area) Shitike Creek (mouth to RM 5, City of Warm Springs, near Hwy 26) Deschutes River (Eagle Creek to Shitike Creek) Deschutes River (Trout Creek to PBR)	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Overgrazing, agricultural conversion, confinement in Ka-Nee-Ta area, roads, development	Abundance, productivity	All	Riparian planting can accelerate the rate of recovery.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian communities	CTWSRO, USFS, ODA, SWCDs, ODFW, watershed councils	Ongoing	High dispersal downstream	Long term	5-15 years	High
Develop grazing strategies that promote riparian recovery	CTWSRO, USFS, ODA, SWCDs, BLM	Ongoing	High dispersal downstream	Long term	5-15 years	High
Eradicate invasive plant species from riparian areas	CTWSRO, USFS, ODA, SWCDs, watershed councils, BLM	Ongoing	Localized	Long term	After multiple years of treatment	Moderate
Install fencing to exclude livestock from riparian areas	CTWSRO, ODA, SWCDs, ODFW	Ongoing	High dispersal downstream	Long term	Riparian restoration (0-5 years)	High
Install off-stream livestock watering	ODFW, CTWSRO, USFS, ODA, SWCD	Expansion of existing effort	Private lands	Ongoing	Riparian restoration (0-5 years)	High
Plant riparian vegetation where appropriate	CTWSRO, USFS, ODA, SWCDs, ODFW, watershed councils	Ongoing	High dispersal downstream	Long term	5-15 years	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTWSRO	Watershed maintenance	Warm Springs River RM 0.0 – 3.5	Likely	Needs to be continued.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.				
		Warm Springs River RM 27.5 - 30 Lower Deschutes River RM 73-84 Beaver Creek RM 0.25-3.5 Beaver Creek RM 14-18 Badger Creek RM 0.5-2.5 Skookum Creek RM 0-1.0		
CTWSRO	IRMP	Warm Springs 5th field HUCs Shitike Creek 5th field HUC	Yes	Adaptive management plan in place, program could be expanded.
SWCDs	Upland improvements, riparian improvements	Private land		Program could be expanded. See State of Oregon programmatic review -- Appendix F.
ODFW	ODFW COID mitigation and enhancement program	Upper Deschutes River, Whychus Creek	No	Limited to small geographical scale. More downstream effects need to be addressed need to be addressed.
USFS	Allotment Management Plan, Forest Management Plans	Metolius 5th field HUCs Whychus 5th field HUCs	Yes	See USFS/BLM Sufficiency Assessment—Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
NRCS	EQUIP, CRP, CREP	Upper Deschutes 4th field HUC	Yes	Programs for property owners to enroll riparian and upland.
ODA	Agricultural Water Quality Management Program	Private land		See State of Oregon programmatic review -- Appendix F.
Upper Deschutes Watershed Council	Various restoration projects	Whychus Creek	Yes	Could be expanded.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The CTWSRO has erected and maintains nearly 70 miles of riparian exclusion fences, constructed water gaps, and off channel watering station for livestock. Constant maintenance of the fence lines must be conducted to keep livestock out and protect the riparian vegetation. Construction of more off channel watering sites or water gaps would help to address part of the issue. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. The USFS requires fence maintenance for all grazing allotments. New fencing may be part of adjustments to existing grazing strategies by the USFS/BLM to promote riparian recovery.				

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	1-Whychus Creek 1-Upper Deschutes River	Altered hydrology, low flows, high temperatures	Water withdrawals, land conversion on uplands, road network	Abundance, productivity	Primarily fry and summer parr	
Improve irrigation conveyance and efficiency	1-Whychus Creek 1-Upper Deschutes River	Low flows, high temperatures	Water withdrawals,	Abundance, productivity	Primarily fry and	Irrigation withdrawals in Whychus Creek dewater sections of the creek

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
			loss during conveyance		summer parr	during summer baseflows.
Lease or purchase water rights and convert to instream	1-Whychus Creek 1-Upper Deschutes River	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	Small tributary flows are often intermittent limiting habitat availability in summer. EDT identified streamflows as a major limiting factor in this area.
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD, CTWSRO, landowners	Ongoing	Point of diversion downstream	Long term	Immediate increase in streamflow	High
Improve irrigation conveyance and efficiency	SWCD, USFS, OWRD, CTWSRO, OWEB, landowners	Expands existing program, proposes new projects	High dispersal downstream	Ongoing – Long term	Increased streamflow (0-5 years)	High
Lease or purchase water rights and convert to instream	OWRD, Oregon Water Trust, PGE, DRC, DBLT, others	Ongoing	Point of diversion to mouth of Deschutes	Long term	Immediate increase in instream flow	High
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion to mouth of Deschutes	Long term	Immediate	High
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTWSRO	IRMP, water quality standards	Warm Springs 5th Field HUCS Shitike Creek 5th field HUC Seekseequa Creek 5th field HUC	Yes in some areas, no in others	Program could be expanded to improve effectiveness.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.				
ODFW	Habitat Program, riparian improvements	Upper Deschutes 4th field HUC	Uncertain	Needs expansion.
OWRD	Stream Flow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Upper Deshcutes 4th field HUC		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust and BOR	Leasing and Purchase of Water Rights	Upper Deschutes 4th field HUC	Uncertain	Program needs expansion.
SWCDs	Improve irrigation efficiency, upland improvements, riparian improvements	Population-wide		See State of Oregon programmatic review -- Appendix F.
ODEQ	Water quality management plans	Upper Deschutes 4th field HUC		See State of Oregon programmatic review -- Appendix F.
USFS, BLM	Water quality restoration plans (WQRP), PACFISH	Upper Deschutes 4th field HUC	Uncertain	WQR Plans identify projects but don't direct implementation of projects. See USFS/BLM Program Sufficiency Assessment -- Appendix E. and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
Watershed Councils	Upland improvements, riparian improvements	Whychus Creek, Lake Creek	No	Program needs additional resources.
NRCS	Upland improvements, riparian improvements	Population-wide	Uncertain	Program could be expanded.
DRC	Flow restoration projects	Upper Deschutes River Whychus Creek	No	Currently have projects in Whychus Creek. Needs to be expanded.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The CTWSRO, ODFW, Watershed Councils, NRCS and Soil and Water Districts have implemented riparian improvements on federal, tribal, state, and private lands to improve base streamflows and other habitat parameters, primarily through construction of riparian corridor fences that exclude livestock grazing and development of off channel watering devices. Public land managers have implemented PACFISH standards for protection and restoration of USFS and BLM lands. Primary constraints on more riparian improvements are personnel and funding. The Deschutes River subbasin has 578 miles of stream protected by instream water rights. Voluntary flow restoration restored 13.4 cfs in 2006, of which 3.2 cfs was permanent. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Manage irrigation return flow to reduce elevated stream temperatures	2- Warm Springs R. 2- Mill Cr. 1- Whychus Cr. 1-Deschutes R.	Altered stream temperatures, degraded water quality	Water withdrawals	Abundance, productivity	Fry dispersal and rearing	
Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	1- Warm Springs R. (RM 7) 1- Shitike Cr. (RM1.5)	Depleted oxygen Nutrient enrichment Bacteria increase	Point source inputs	Abundance, productivity	Fry dispersal and rearing	Warm temperatures reduce the dissolved oxygen capacity of the water.
Reduce chemical pollution inputs	Agricultural lands throughout population	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity		

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
			point source inputs			
Implement Agricultural Water Quality Management Program	Agricultural lands throughout population	Degraded upland processes, altered hydrology, water quality, altered sediment routing	Land conversion and agricultural practices	Abundance, productivity	Fry dispersal and rearing	Recent conservation measures have greatly reduced sediment inputs.
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	1- Deschutes R. Pelton Dam to Trout Cr. 1- Warm Springs MaSAs and MiSAs 1- Shitike Cr. MaSAs and MiSAs 2- Potential MaSAs in Metolius 1- Potential MaSAs in Whychus	Degraded upland processes, floodplains, riparian areas, altered hydrology, altered sediment routing	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Spawning, incubation, fry dispersal, rearing, over-wintering	The Deschutes River and several westside tributary reaches are included on the 2002 ODEQ 303(d) list of water quality limited streams. The lower Deschutes River exceeds temperature criteria for salmonid rearing from White River to Pelton Dam. Water temperatures in lower reaches of Warm Springs River and Shitike Creek can exceed 70°F from mid to late summer. EDT identified water temperature during incubation as a major limiting factor in lower Shitike Creek, Beaver Creek, and several other stream reaches (NPCC 2004b). Reduced streamflows negatively affect water quality. Excessive sediment loads can also reduce water quality in the Warm Springs River, primarily from runoff in lower tributaries including Quartz and Coyote creeks.
Continue TMDL monitoring	Population-wide	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	All	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Manage irrigation return flow to reduce extreme stream temperatures	SWCDs	Ongoing	High dispersal downstream	Less than 5 years	Immediate	High
Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	ODEQ, municipalities	Ongoing	Dispersal downstream	Ongoing – Long term	Variable	Moderate
Reduce chemical pollution inputs	ODEQ, WyEast RC&D, others Municipal sewage treatment plants		Dispersal downstream	Ongoing – Long term	Reduce chemical pollution immediately	High
Implement Agricultural Water Quality Management Program	ODA, SWCD		Subbasin-wide	Ongoing – Long term	Long term	High
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD	Ongoing	Subbasin-wide, high dispersal downstream	Long term	Up to 15 years	High
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.					
Status of Existing Programs through which Actions are Implemented					
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale	
ODEQ	CWA Section 401	Upper Deschutes 4th field HUC		See State of Oregon programmatic review -- Appendix F.	
CTWSRO	CWA Section 401, Water Quality Standards, Integrated Resource Management Plan	Warm Springs 5th field HUCs Shitike Creek 5th field HUC	Likely	Needs expansion.	
ODA	Agricultural Water Quality Management Program	Middle Deschutes River Whychus Creek		See State of Oregon programmatic review -- Appendix F.	
USFS, BLM	Stream Restoration Program (PacFish/NWFP)	Metolius River/5th field HUCs Whychus Creek5th field HUCs Middle Deschutes River 5th field HUCs	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).	
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)					
ODA's Agricultural Water Quality Management Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.					

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Continue to promote no-till and other seeding techniques that reduce erosion where site conditions are suitable	Subbasin-wide	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Restore native upland plants	Subbasin-wide	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Upgrade or remove problem forest roads	Forest lands	Altered hydrology, sediment routing	Road network	Abundance, productivity	All	
Utilize appropriate fire suppression techniques, implement mitigation measures	Subbasin-wide	Altered hydrology, sediment	Conversion of vegetative communities	Abundance, productivity	All	Appropriate mitigation methods minimize suppression impacts on habitat.
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Employ BMPs to minimize unnatural rates of erosion	Subbasin-wide	Altered hydrology, sediment routing, water quality	Upland land use practices, erosion, loss of water storage capacity	Abundance, productivity	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Continue to promote no-till and other seeding techniques that reduce erosion where site conditions are suitable	SWCD	Existing program	Croplands, MaSAs	Ongoing	Reduce runoff, sediment supply, immediate increase in base flow	High
Restore native upland plants	USFS, BLM, NRCS, SWCDs, watershed councils, CTWSRO, BIA	Ongoing	High dispersal downstream	Juniper control can be quick, other actions such as control of invasive plants may take 20 years or more	0-20 years	High
Upgrade or remove problem forest roads	CTWSRO, USFS, ODOT, ODF	Ongoing	High dispersal downstream	Long term	Immediate for sediment, other parameters 5-15 yrs	High
Utilize appropriate fire suppression techniques, implement mitigation measures	CTWSRO, USFS, BLM	Ongoing	Areas where fires have occurred	Long term	5-15 yrs	High
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to minimize unnatural rates of erosion	SWCD, USFS, ODA, ODF, BLM, CTWSRO, watershed councils, NRCS, private landowners	Ongoing	High dispersal downstream	Intermediate	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS,SWCD, Private Landowners	CRP, CREP, EQUIP, WHP	Middle Deschutes 5th field HUC Metolius 5th field HUCs Warm Springs 5th field HUCs Lower Deschutes River RM 74-100 Whychus Creek	Likely	Needs expansion.
CTWSRO	Watershed Restoration	Coyote Creek / Quartz Creek 5th field watershed Beaver Creek 5th field watershed Shitike Creek 5th field watershed	No	Program needs additional resources—expand in scope.
ODFW	Watershed Restoration	Whychus Creek Metolius River	Uncertain	Needs expansion.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
USFS, BLM	Stream Restoration Program (PacFish/NWFP)	Metolius River 5th field HUCs Whychus Creek 5th field HUCs	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.				
		Middle Deschutes River		
CTWSRO	IRMP	Warm Springs 5th field HUCs Shitike Creek 5th field HUC	Yes	Guided by adaptive management plan for next 10 years--may need expansion in future.
CTWSRO, USFS, BLM	Fire suppression mitigation approaches	Population-wide	Likely	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

9.3.4 Habitat Strategies and Actions for Crooked River Steelhead Population

Primary limiting factors: degraded channel structure and complexity and floodplain connectivity, degraded riparian condition, high water temperature, low flows, altered hydrology sediment routing and lack of fish passage.

Primary threats: grazing and agricultural practices, urban development, off highway vehicle use, irrigation withdrawal, dams, lack of floodplain connectivity.

Geographic area designations: Allen Cr-1 (Rm 0 – Rm 4); Crooked MS-1 (Rm 6 – Rm 7); Crooked MS-2 (Rm 7 – Rm 14); Crooked MS-3 (Rm 14 – Rm 30); Crooked MS-4 (Rm 31 – Rm 45); Crooked MS-5 (Rm 45 – Rm 46); Crooked MS-6 (Rm 46 – Rm 51); Crooked MS-7 (Rm 51 – Rm 55); Crooked MS-8 (Rm 55 – Rm 62); Crooked MS-9 (Rm 62 – Rm 70); Crooked R. above Bowman Dam; Little McKay Cr-1 (Rm 0 – Rm 3); McKay Cr-1 (Rm 0 – Rm 5); McKay Cr-2 (Rm 5 – Rm 10); McKay Cr-3 (Rm 10 – Rm 14); McKay Cr-4 (Rm 14 – Rm 16); McKay Cr-5 (Rm 16 – Rm 19); Ochoco Cr-1 (Rm 0 – Rm 5); Ochoco Cr-2 (Rm 5 – Rm 10); Ochoco Cr. above Ochoco Dam.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority, 3-third priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect the highest quality habitats through acquisition or conservation easements	1- Crooked MS-1,8,9 1- McKay Cr-1,3 1- Ochoco Cr-2 2- Crooked MS-3,4,5,6 2- McKay Cr-2 2- Ochoco Cr-1 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	Abundance, productivity	All	Additional riparian fencing on McKay and Ochoco creeks would greatly improve riparian conditions and recruitment of woody vegetation.
Adopt and manage Cooperative Agreements	Private and public lands	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	Abundance, productivity	All	Continue stream channel restoration on City of Prineville property and expand up and downstream.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Conserve rare and unique functioning habitats	1- Crooked MS-1,2,9 2- McKay Cr-4,5 2- Little McKay Cr-1 2- Crooked MS-7	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	All	Abundance, productivity	All	
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	1- Entire population	All factors	All	Abundance, productivity	All	Apply BMP's and other existing habitat protection laws to the entire population to prevent habitat degradation.
Conduct outreach to resource users and managers	1- Entire population	All factors	All	All	All	Program outputs will be improved as knowledge of ecological processes, hydrological processes, and land use management is expanded.
Special management designated on public lands	1- Crooked MS-1,2,9	All factors	All	All	All	Management of Wild and Scenic River

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements	BLM, USFS, Crooked River Watershed Council (CRWC), City of Prineville, Deschutes Basin Land Trust	Ongoing	McKay MASA, Lower Crooked MASA, Lower Ochoco MASA	Immediate	Variable depending on habitat condition	High
Adopt and manage Cooperative Agreements	CRWC, City of Prineville, private landowners, ODFW, Ochoco lumber,	Ongoing	Ent ire subbasin	Long term	Variable depending on habitat condition	Likely
Conserve rare and unique functioning habitats	BLM, USFS, ODFW	Ongoing	1- Crooked MS-1,2,9 2- McKay Cr-4,5 2- Little McKay Cr-1 2- Crooked MS-7	Immediate	Variable depending on habitat condition	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	SWCD, USFS, ODA, NRCS, CRWC, BLM, counties, private landowners	Ongoing	Entire subbasin	Long term	Degradation stop immediately, habitat recovery 15-25 years depending on status	Unknown, depends upon action taken as a result of being more informed
Conduct outreach to resource users and managers	ODFW, CRWC, BLM, USFS, NOAA Fisheries, SWCD's, OSU extension, CTWSRO, PGE	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS and BLM	Special Management Area designations PACFISH, Wild and Scenic River Corridors	Crooked MS-1,2,-9 McKay Cr-4, Cr-5 Little McKay Cr-1	Likely	Continual implementation of programs. See USFS/BLM Program Sufficiency Assessment -- Appendix E. Currently no additional opportunities to expand programs

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
				on BLM lands.
USDA FSA/SWCD's	CREP/CRP	Agricultural lands throughout population	Likely	Additional programs can be enrolled, and programs are not permanent in duration. See State of Oregon Programmatic review -- Appendix F.
ODA/SWCD's	Agricultural Water Quality Management Program	Agricultural lands throughout population	Uncertain	See State of Oregon Programmatic review -- Appendix F.
Local Government	County planning and zoning, City of Prineville Comprehensive Plan	Private lands throughout population	Uncertain	Riparian protection not adequate. Discharge of partially treated wastewater from city facility into Crooked River.
PGE	Lower Crooke MASA, Lower Ochoco MASA	Upper Population	Uncertain	Newly implemented program, results not yet available.
NGOs	Lease or purchase of land or instream water rights	Private lands throughout population	No	Limited opportunities arise, but programs can be expanded when opportunities become available.
Watershed Councils	CRWC	Population-wide	Uncertain	Water council currently active and successful, however success and future is dependent on ability to continue procuring funds.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guidelines for FS and BLM grazing management remains challenging in some locations. FSA programs that protect riparian areas and upland watersheds include CRP, which pays landowners not to farm highly erodible soils, and the CREP program that pays landowners for setting riparian corridors side from grazing and farming. The long-term effectiveness of both programs is limited by the relatively short duration of the contracts, which ranges from 10-15 years. ODA's Agricultural Water Quality Management Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements.				

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Replace or remove barriers blocking passage including dams, road culverts, irrigation structures, infiltration galleries	1- Rice Baldwin Dam 1- Stearns Dam 1- Seamus Dam 1- Parga Dam 2- Ochoco Creek (Prineville Country Club) 2- Bowman Dam 2- Ochoco Dam 2- Opal Springs Dam	Impaired fish passage	Dams, culverts, instream structures	Abundance, spatial structure, productivity	Primarily adults and 0+juveniles	Passage has been provided at the Crooked River Central and Peoples Irrigation diversions. It is likely that passage will be provided at Seamus and Parga Dams by 2011. Passage at other dams and diversions will be a greater challenge.
Maintain irrigation diversions and screens	1-Where diversions exist throughout population	Impaired fish passage	Irrigation diversions	Abundance, spatial structure, productivity	Primarily juveniles, but also adults at facilities with ladders.	All known diversions are maintained and generally meet screening criteria.
Provide screening at 100% of irrigation diversions	1-Peoples Irrigation 2-private irrigation diversions	Entrainment in canals	Irrigation diversions	Abundance, spatial structure, productivity	Juveniles	Screening of Peoples irrigation is planned. Significant progress in screening in

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
						recent years, including each of Ochoco Irrigation District's diversions. Most remaining screening issues in McKay Cr.
Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Remove/replace barriers blocking passage including dams, road culverts and irrigation structures	CRWC, BLM, USFS, ODFW, private landowners	Ongoing	Access between upstream and downstream habitats	Immediate	Immediate	High
Maintain irrigation diversions and screens	ODFW, private landowners, irrigation districts	Ongoing	Diversions subbasin-wide	Based on funding	Immediate	High
Provide screening at 100% of irrigation diversions	ODFW Fish Passage and Screening	Ongoing	Access between upstream and downstream habitats	Immediate as need is identified	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	**Program Name**	**Geographic Locations**	**Sufficient* (yes, likely, uncertain, no)**	**Sufficiency Rationale**
CRWC, BLM, ODFW, BOR, NRCS, Ochoco Irrigation, private landowners	Fish passage and screening, state funding and federal funding	Rice Baldwin Dam, Stearns Dam, Seamus Dam, Parga Dams, Ochoco Creek, Bowman Dam, Ochoco Dam, Opal Springs Dam.	Likely	Passage has been provided at the Crooked River Central and Peoples Irrigation diversions. It is likely that passage will be provided at Seamus and Parga Dams by 2011. Passage at other dams and diversions will be a greater challenge.
ODFW	Fish Passage/Screening, State program and federal funded	Population-wide	Uncertain	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding. See State of Oregon programmatic review -- Appendix F.
CTWSRO/ODFW	Salmon and Steelhead Reintroduction Plan	Areas above Pelton complex	No	Adaptive plan over life of FERC license.
ODOT	Culvert replacement or retrofit	Population-wide		See State of Oregon programmatic review -- Appendix F.
USFS and BLM	Culvert replacement	Population-wide	USFS likely with current program.	Needs expansion.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
A comprehensive fish screen inventory needs to be completed throughout the population. The Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) provides guidance that will help prioritize culvert replacements for this population. Fish will not be able to pass beyond Crooked MS-1 without passage at Opal Springs Dam, successful construction of a fish ladder is crucial.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	**Geographic Locations (1-first priority, 2-second priority)**	**Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Reconnect floodplains to	1- Crooked MS-4,5,6	Degraded floodplain,	Removal of interaction	Abundance,	Primarily 0 to	Floodplains and channels that are in

Strategy 3. Maintain and restore floodplain connectivity and function.						
channels	1- McKay Cr-1,2,3,4 2- Little McKay Cr-1 2- Crooked MS-3,7,8 2- McKay Cr-5,6 2- Allen Cr-1 2-Ochoco Cr-1,2 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	degraded riparian area, channel structure	between river and floodplain, grazing, agricultural use, loss of beaver dams	productivity	2-age rearing and 2-age migrants	balance are essential for proper stream function. Improved livestock grazing and agricultural practices necessary for successful restoration. Floodplain connection in Crooked MS-8 is highly desirable, but landowner cooperation is necessary.
Reconnect side channels and off-channel habitats to stream channels	1- Crooked MS-4,5,6 1- McKay Cr-1,2,3,4 2- Little McKay Cr-1 2- Crooked MS-3,7,8 2- McKay Cr-5,6 2- Allen Cr-1 2-Ochoco Cr-1,2 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Off channel habitat important juvenile rearing habitat. Improved livestock grazing and agricultural practices necessary for successful restoration. Floodplain connection in Crooked MS-8 is highly desirable, but landowner cooperation is necessary.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	1-McKay Cr 1,2,3,4,5 1-Little McKay Cr 1 1-Ochoco Cr 1,2 2-Allen Cr 1 3-Crooked above Bowman 3-Ochoco Cr above Ochoco Dam	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity	All	As riparian areas recovery, beaver recolonization occurs naturally.
Restore wet meadows and wetlands	1- Crooked MS-4,5,6 1- McKay Cr-1,2,3,4 2- Little McKay Cr-1 2- Crooked MS-3,7,8 2- McKay Cr-1,4 2- Allen Cr-1 2-Ochoco Cr-1,2 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands and wet meadows	Abundance, productivity	Primarily fry and age 0+	Restoration of wet meadows and wetlands will be by-product of floodplain and side channel restoration; however, specific projects may be required to reach acceptable status.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain habitats.	CTWSRO, ODFW, CRWC, BLM, SWCD's, USFS, PGE, ODOT, City of Prineville	Ongoing	High dispersal downstream from site	Long term	5-15 years	Likely, dependent on further landowner cooperation
Reconnect side channels and off-channel habitats to stream	CTWSRO, ODFW, CRWC, SWCD, USFS, BLM, PGE,	Ongoing	High dispersal downstream from site	Long term	5-15 years	Likely, dependent on

Strategy 3. Maintain and restore floodplain connectivity and function.						
channels.	ODOT					further landowner cooperation
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	CTWSRO, ODFW, USFS, BLM	Ongoing	Subbasin-wide	Long term	Within 15 years	Likely
Restore wet meadows and wetlands	CTWSRO, ODFW, CRWC, BLM, SWCD's, USFS, PGE, ODOT, City of Prineville	Ongoing	Subbasin-wide	Long term	Within 15 years	Likely

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CRWC, City of Prineville	Crooked River stream channel restoration	Crooked MS-5	No	Engineering for project complete, implementation expected summer 2010. Project only restores one stream segment, more restoration necessary in this reach and others. Efforts to re-establish floodplain connectivity in other reaches of the Crooked River were not successful due to channel degraded channel condition, altered hydrology and project design.
CRWC, Ochoco Lumber, ODFW	Ochoco Creek Enhancement, Ochoco Mill Site	Ochoco CR-1	No	Although this project will improve fish habitat within the project boundaries, similar strides are necessary in Ochoco CR-1 and Ochoco CR-2
CRWC, private landowners, ODFW	Middle McKay passage protection, stream restoration	McKay Cr-2,3 Allen Creek Cr-1	Uncertain	Projects will create fish passage and restore natural stream channels. However, landowner cooperation is necessary for project completion and restoration needs to be expanded throughout entire stream and some tributaries.
NRCS,SWCD, USDA FSA, Private Landowners	CREP/CRP	Private lands throughout population	Uncertain	An effective program that could be expanded to more landowners. See State of Oregon programmatic review -- Appendix F.
BLM, Oregon State Parks,	Wild and Scenic Rivers	Crooked MS-1,2,3 (RM 6-17) Crooked MS-9	Yes	See State of Oregon and Federal agencies' programmatic reviews.
ODA/SWCD	Agricultural Water Quality Management Program	Private lands	No	See State of Oregon programmatic review -- Appendix F.
USFS	Stream Restoration Program (PACFISH)	Forest lands only when specifically identified that passive restoration is not working	Likely	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. Program implementation needs to expand in scope. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
CRP in uplands and riparian protection provide short-term benefits, however longer periods are required to restore stream channel and habitat. Habitat benefits of CRP enrollments are dependent upon agreements between participating agencies and landowners. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 3. Maintain and restore floodplain connectivity and function.
The success of all stream channel and riparian restoration is dependent on cooperation between landowners and government agencies. Proper land management practices must be adopted by landowners and natural resource managers to assure that further habitat degradation does not occur. Channel and floodplain restoration projects in the recovery area will require long-term monitoring agreements between the CRWC and landowners.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority, 3-third priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form, includes berm and levee removal	1- Crooked MS-4,5,6 1- McKay Cr-1,2,3,4, 1- Ochoco Cr 2 2- Little McKay Cr-1 2- Crooked MS-3,7,8 2- McKay Cr-5,6 2- Allen Cr-1 2-Ochoco Cr-1, 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Degraded channel structure and complexity, floodplain, degraded riparian area, altered hydrology, degraded water quality, sediment routing	Grazing, agricultural practices, channelization, berms, roads, railroad bank armoring, floodplain, loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Channelization, berm construction, and bank armoring, following floods has isolated the stream from the floodplain in many areas. Large wood and other instream habitat complexity is lacking. Efforts to re-establish floodplain connectivity in other reaches of the Crooked River were not successful due to channel degraded channel condition, altered hydrology and project design.
Increase role and abundance of wood and large organic debris in streambeds	1- McKay CR-1,2,3,4,5 1- Little McKay Cr-1 1- Ochoco CR-1,2 2- Crooked MS- 3,4,5,6,7,8,9 2- Allen Cr-1 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Degraded channel structure and complexity, floodplain, degraded riparian area , altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Limited opportunity to recruit and maintanin large woody debris in mainstem Crooked River. Agricultural practices have nearly eliminate woody vegetation from riparian areas and woody vegetation rehabilitation is necessary for entire Crooked River, McKay CR-1,2,3,4 and Ochoco CR-1 and 2. Bowman and Ochoco Dams prevents LWD recruitment from above the dam.
Increase instream habitat through manual placement of structures	1- McKay Cr-1,2,3,4,5 1- Little McKay Cr-1 1- Ochoco Cr 1,2 2- Allen Cr-1 2- Crooked MS- 3,4,5,6,7,8	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Considered an active form of restoration while habitat conditions are restored through more passive efforts
Stabilize streambanks with passive restoration processes	1- Crooked MS-4,5,6 1- McKay Cr-1,2,,4.5 1- Little McKay Cr-1 2- Crooked MS-3,7,8 2- McKay Cr-3 2- Allen Cr-1	Degraded channel structure and complexity, floodplain connectivity, degraded riparian areas, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily 0 to 2-age rearing and 2-age migrants	Passive restoration will not be adequate in lower Crooked River valley. Passive restoration should be considered above Bowman and Ochoco Dams to prepare for steelhead recovery in coming decades.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
	2-Ochoco Cr-1,2 3- Ochoco Cr. (above Ochoco Dam) 3- Crooked R. (above Bowman Dam)					

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form, includes berm and levee removal	CTWSRO, ODFW, SWCD, USFS, BLM, CRWC, City of Prineville	Ongoing	High dispersal downstream	Long term	5-15 years	Likely
Increase role and abundance of wood and large organic debris in streambeds	ODFW, USFS, BLM, PGE, CTWSRO, CRWC	Ongoing	Localized to treatment area	Long term	Immediate	High
Increase instream habitat through manual placement of structures	ODFW, USFS, BLM, CTWSRO, CRWC, private landowners	Ongoing	Limited application throughout population	Long term	Immediate	High
Stabilize streambanks	CTWSRO, ODFW, SWCD, CRWC, USFS, BLM, ODA, City of Prineville	Ongoing	High dispersal downstream	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS,SWCD, USDA FSA, Private Landowners	CREP/CRP	Riparian and upland areas throughout population	Uncertain	An effective program for both upland and riparian protection, but could be expanded to additional private lands. See State of Oregon programmatic review -- Appendix F.
BLM Prineville District	Various range and upland restoration projects.	BLM lands	Likely	Most lands currently meeting BLM Standards and Guidelines continued monitoring is needed to unsure long-term compliance.
BLM, Oregon State Parks, CTWSRO	Wild and Scenic Rivers	Crooked MS-1,2,3, 9 (RM 6-17, 62-70) Crooked MS-9	Likely	See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODA/SWCD	Agricultural Water Quality Management Program	Throughout population	No	See State of Oregon programmatic review -- Appendix F.
USFS	Stream Restoration Program (PACFISH)	Forest lands only when specifically identified that passive restoration is not working	Likely	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. Needs to be expanded to more streams in Trout Creek Subbasin. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (UDSA-FS, 2005).
CRWC	Various restoration projects	Entire Crooked River Subbasin	Uncertain	Project capacity currently at a maximum, expansion of council personnel could improve recovery effort.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

CRP in uplands and riparian protection provide short-term benefits, however longer periods are required to restore stream channel and habitat. Habitat benefits of CRP enrollments are dependent upon agreements between participating agencies and landowners. Riparian fencing must be maintained to assure that the riparian vegetation can re-establish and eventually provide a source of LWD.

The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.
Channel and floodplain restoration projects in the recovery area will require long-term monitoring agreements between the CRWC and landowners.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority, 3-third priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian communities including vegetative planting	1- Crooked MS-3,4,5,6,7,8 1- McKay Cr-1,2,3,4,5 1- Ochoco Cr-1,2 1- Allen Cr-1 2- Crooked MS-1,2,9 2- Little McKay Cr-1 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Livestock grazing, agricultural conversion, roads, bank armoring, residential development, loss of beaver dams	Abundance, productivity	All	Past grazing practices throughout the subbasin have caused riparian degradation. Current practices, though improved, continue to limit recovery. Heavy off road vehilcle use has lead to severe riparian degradation in McKay Cr-5. Riparian vegetation contributes little to LWD recruitment and canopy cover. Streambank erosion and loss of riparian vegetation has led to undesirable width-to-depth ratios throughout the watershed
Develop grazing strategies that promote riparian recovery	1- Crooked MS-3,4,5,6,7,8 1- McKay Cr-1,2,3,4,5 1- Ochoco Cr-1,2 1- Allen Cr-1 2- Little McKay Cr-1 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Overgrazing	Abundance, productivity	All	Significant opportunity to improve grazing strategies.
Eradicate invasive plant species from riparian areas	Where opportunities exist throughout the subbasin	Degraded riparian communities	Conversion of natural riparian vegetative communities	Abundance, productivity	All	
Install/maintain fencing to exclude livestock from riparian areas	1- Crooked MS-3,4,5,6,7,8 1- McKay Cr-1,2,3,4,5 1- Ochoco Cr -2 2- Allen Cr-1 2- Little McKay Cr-1 2- Ochoco Cr-2 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Overgrazing	Abundance, productivity	All	Several locations will benefit from livestock exclusion.
Install off-stream livestock watering	Throughout entire subbasin	Degraded riparian communities, sediment routing	Overgrazing	Abundance, productivity	All	
Plant riparian vegetation where appropriate	1- Crooked MS-3,4,5,6,7,8 1- McKay Cr-1,2,3,4,5 1- Ochoco Cr-1,2	Bank degradation, degraded riparian communities, LWD recruitment, temperatures, flow, sediment routing	Overgrazing, agricultural conversion, roads,	Abundance, productivity	All	Natural vegetation restoration generally occurs without planting, some planting occurs along with

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
	1- Allen Cr-1 2- Crooked MS-1,2,9 2- Little McKay Cr-1 3- Crooked R. (above Bowman Dam) 3- Ochoco Cr. (above Ochoco Dam)		urban development			fencing projects and CREP projects.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian communities including vegetative planting	USFS, SWCD's, ODFW, CRWC, BLM, OWEB, private landowners	Ongoing	High dispersal downstream	Long term	Riparian restoration (10-25 years)	Likely
Develop grazing strategies that promote riparian recovery	USFS, ODA, SWCD's, BLM, CRWC, private landowners	Ongoing	High dispersal downstream	Long term	Riparian restoration (10-25 years)	Likely
Eradicate invasive plant species from riparian areas	CTWSRO, USFS, ODA, SWCD's, CRWC, BLM, private landowners	Ongoing		Immediate	Riparian restoration (10-25 years)	Uncertain
Install/maintain fencing to exclude livestock from riparian areas	NRCS, , ODA, SWCD's, ODFW, USFS, BLM, private landowners	Ongoing	High dispersal downstream	Immediate	Riparian restoration (10-25 years)	Likely
Install off-stream livestock watering	USFS, ODA, SWCD, CRWC, private landowners	Expansion of existing effort	Private lands	Ongoing	Riparian restoration (10-25 years)	Likely
Plant riparian vegetation where appropriate	USFS, SWCD's, ODFW, CRWC, BLM, OWEB, private landowners	Ongoing	High dispersal downstream	Long term	Riparian restoration (10-25 years)	Likely

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
BLM, Oregon State Parks, CTWSRO	Wild and Scenic Rivers	Crooked MS-1,2,3 (RM 6-17) Crooked MS-9	Likely	See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
USFS	Stream Restoration Program (PACFISH)	Forest lands	Likely	Needs to be expanded to more streams in Trout Creek Subbasin. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.
NRCS,SWCD, USDA FSA, Private Landowners	CREP	Throughout population	Uncertain	An effective program for both riparian protection and restoration, but could be expanded to additional private lands.
ODA	Agricultural Water Quality Management Program	Throughout population		See State of Oregon programmatic review -- Appendix F.
CRWC/OWEB	Various restoration projects	Throughout population	Uncertain	Effective program for developing restoration/protection projects and supplying outreach information on resource management. Participation could be expanded.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The Forest Service Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funds where it is most needed.

Public land managers have implemented PACFISH standards for protection and restoration of USFS and BLM lands. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS,

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.
2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funding where it is most needed. The USFS/BLM requires fence maintenance for all grazing allotments. New fencing may be part of adjustments to existing grazing strategies by the USFS/BLM to promote riparian recovery.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	1- Crooked MS-3,4,5,6,7 1- McKay Cr-1,2,3 1- Allen Cr-1 1- Ochoco Cr-1,2 2- Crooked R. (above Bowman Dam) 2- Ochoco Cr. (above Ochoco Dam)	Altered hydrology, low flows, high temperatures	Water withdrawals, land conversion on uplands, road network	Abundance, productivity	Primarily fry and summer parr	Major flows of Crooked River and its tributaries diverted for irrigation purposes. Conserved flows from the Crooked River above Bowman Dam and Ochoco Creek above Ochoco Dam would benefit downstream fish populations. Flow gauges at diversions could be used to regulate irrigation allocations.
Improve irrigation conveyance and efficiency	1- Crooked MS-3,4,5,6,7 1- McKay Cr-1,2,3 1- Allen Cr-1 1- Ochoco Cr-1,2 2- Crooked R. (above Bowman Dam) 2- Ochoco Cr. (above Ochoco Dam)	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Primarily fry and summer parr	Conversion of flood to sprinkler irrigation, piping, irrigation efficiency improvement, and diversion gauging would increase flows.
Lease or purchase water rights and convert to instream	1- Reallocation of Prineville Reservoir 1- Where available	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and summer parr	Most water withdrawals are not monitored for compliance.
Water retention structures	Population-wide	Altered hydrology, low flows	Degradation on uplands	Abundance, productivity	Primarily fry and summer parr	Many water retention structures would not be necessary if riparian areas were left intact and uplands were properly managed thereby increasing the water retention abilities of the soil.
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Altered hydrology, low flows, high temperatures, impaired natural functions and processes on uplands, floodplains, riparian areas	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Primarily fry and summer parr	Juniper encroachment and consequential reduction of native grasses, shrubs, and forbs has reduced retention of precipitation in uplands. Flow fluctuations are now larger than they were historically. High flows have scoured channels reducing habitat diversity.
Assess existing and future water needs, complete statewide inventory of above	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial	All stages	New programs in development

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs				structure, diversity		

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD, , BOR, irrigation districts, landowners, OWRD	Expands existing program, new projects	Croplands throughout subbasin	Based on funding	Immediate increase in streamflow; habitat diversity, floodplain connection (0-5 yrs)	Likely
Improve irrigation conveyance and efficiency	SWCD, USFS, OWRD, OWEB, landowners, CRWC	Expands existing program, proposes new projects	High dispersal downstream	Ongoing	Increased streamflow (0-15 years)	Likely
Lease or purchase water rights and convert to instream	OWRD, Oregon Water Trust, PGE, DRC, BOR	Ongoing	Point of diversions to mouth of Crooked	Long term	Immediate increase in instream flow	Uncertain
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversions to mouth of Crooked	Long term		Likely
Water retention structures	SWCD's	Ongoing	Uplands	Intermediate	0-15 years	Uncertain
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD, USFS, OWRD, OWEB, ODFW, CTWSRO, landowners	Ongoing	Subbasin-wide	Intermediate	Up to 15 years	Uncertain
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Likely

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
BLM	Various projects related to rangeland improvements in uplands	BLM lands	Uncertain	Effective programs. Long-term monitoring of effectiveness is needed. See USFS/BLM Program Sufficiency Assessment--Appendix E.
NRCS,SWCD, FSA, Private Landowners	CRP, CREP	Riparian and upland areas within population	No	An effective program for both upland and riparian protection, but could be expanded to additional private lands.
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use	Specific locations determined by opportunities		See State of Oregon programmatic review -- Appendix F.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.				
	Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment			
Oregon Water Trust	Lease water rights and return instream	Specific locations determined by opportunities	Uncertain	Program works well, could be expanded with more willing landowners. Need assurance that instream leases remain instream.
SWCD, NRCS	Various irrigation efficiency improvements, CRP, CREP	Specific locations determined by opportunities	Uncertain	Needs expansion.
ODA/SWCD	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Many landowners have adopted modern irrigation techniques; however downstream irrigators generally take unused water. Monitoring of irrigation withdrawals with flow gauges is essential before the benefits of conservative water management are realized. However, irrigation waters should not be returned to streams if they will compromise the water quality of essential habitats. The BOR, as required in the Columbia River Biological Opinion, is required to identify and assist with passage improvement design and flow restoration.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Manage irrigation return flow and wastewater effluent to improve water quality	1- Crooked MS-1,2,3,4,5,6,7 1- McKay Cr-1,2,3 1- Ochoco Cr-1,2 2- Allen Cr-1 2- Crooked R. (above Bowman Dam) 2- Ochoco Cr. (above Ochoco Dam)	Altered stream temperatures, degraded water quality	Land use practices, water withdrawals, pesticides, fertilizers, herbicides, raw sewage	Abundance, productivity	Fry dispersal and rearing	Returns contain multiple pollutants, excessive nutrients, and have increased temperatures leading poor downstream water quality and reduced dissolved oxygen capacity,
Implement Agricultural Water Quality Management Program	Agricultural lands throughout population	Degraded upland processes, altered hydrology, water quality, altered sediment routing	Land conversion and agricultural practices	Abundance, productivity	Fry dispersal and rearing	
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Degraded upland processes, floodplains, riparian areas, altered hydrology, altered sediment routing	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Eggs, fry, juveniles, adults	There are opportunities to improve irrigation methods and reduce runoff from agricultural fields reducing nutrient loading and pollution of streams.
Continue TMDL monitoring	Population-wide	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	All	
Permit and enforce actions that could affect water quality	Population-wide	Water quality	Land use practices	Abundance, productivity, diversity	All	Directed actions at known sources of pollution should be addressed through BMP's and restoration projects.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Manage irrigation return flow to reduce extreme stream temperatures	SWCD's, Irrigation Districts	Ongoing	High dispersal downstream	Less than 5 years	Immediate	Likely
Implement Agricultural Water Quality Management Plan	ODA, SWCD		Subbasin-wide	Ongoing	Variable	Likely
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD	Ongoing	Subbasin-wide, high dispersal downstream	Intermediate	Up to 15 years	Uncertain
Continue TMDL monitoring	USFS, SWCD, ODEQ, CRWC	Ongoing	Subbasin-wide	Ongoing	Immediate	High
Permit and enforce actions that could affect water quality	ODA, SWCD, Municipalities, CDs, USFS, BLM, Irrigation Districts, private landowners, ODEQ	Ongoing	High dispersal downstream	Ongoing	Immediate	Uncertain, degree of implementation is unknown

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
BLM	Various projects related to rangeland improvements in uplands	BLM lands	Uncertain	Effective programs. See USFS/BLM Program Sufficiency Assessment -- Appendix E.
FSA, NRCS,SWCD, Private Landowners	CRP, CREP	Riparian and upland areas throughout population	Uncertain	An effective program for both upland and riparian protection, but could be expanded to additional private lands. See State of Oregon programmatic review -- Appendix F for SWCD.
ODA/SWCD	Agricultural Water Quality Management Program	Throughout population	Uncertain	See State of Oregon programmatic review -- Appendix F.
USFS	Stream Restoration Program (PACFISH)	USFS lands	Uncertain	Needs expansion. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy.
ODEQ	Water Quality	Subbasin-wide	Likely	See State of Oregon programmatic review – Appendix F
ODEQ/EPA	Pesticides/Toxics	Subbasin-wide	Likely	See State of Oregon programmatic review – Appendix F, for ODEQ
Municipalities	Public Works	Crooked MS- 3,4,5,6	No	Treatments of sewage returns unacceptable

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funding for riparian planting where it is most needed.

Implementation of PACFISH standards and guides for Forest and BLM programs, in conjunction with Forest Plan Management Area allocations, has been highly successful for passive upland restoration over most of this population's area.

The TMDLs set loading capacity to achieve water quality standards. To address high summer water temperatures, near stream vegetation disturbance, channel widening and low flows are the existing sources of increased solar radiation loading. Achievement of the TMDL targets is dependent of determination of system potential vegetation. During TMDL development, the best professional judgment of the team described the potential streamside shade-producing vegetation broadly, as continuous tree-belts on each side of the river.

While permit processes implemented by the US Army Corps of Engineers are thorough and actions authorized are protective of aquatic resources, the program lacks personnel resources to insure that terms and conditions of permitted actions are followed. In addition, this agency lacks resources to adequately monitor waterways for non-permitted actions or act upon non-permitted situations reported by other agencies or private parties. See State of Oregon programmatic review -- Appendix F for ODSL.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority, 3- third priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Remove junipers	1-Crooked MS-3,4,5,6,7,8 1-McKay Cr-3,4,5 1-Allen Cr-1 1- Ochoco Cr-2 2- Crooked above (Bowman Dam) 2- Ochoco (above Ochoco dam)	Altered hydrology	Loss of water storage capacity	Abundance, productivity	All	
Restore native upland plants and remove noxious weeds	1-Crooked MS-3,4,5,6,7,8,9 1-McKay Cr-1,2,3,4,5 1-Allen Cr-1 1- Ochoco Cr-2 2- Ochoco Cr-1 3- Crooked above (Bowman Dam) 3- Ochoco (above Ochoco dam)	Altered hydrology, sediment routing	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	
Upgrade or remove problem forest roads	1- McKay Cr-4,5 1- Little McKay Cr-1	Altered hydrology, sediment routing	Road network	Abundance, productivity	All	
Promote reforestation and fuels management	1- McKay Cr-4,5 1- Little McKay Cr-1	Altered hydrology, sediment	Conversion of vegetative communities	Abundance, productivity	All	
Demonstration projects to restore forest health and resilience to wildfire	Private forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to minimize unnatural rates of erosion	Subbasin-wide	Altered hydrology, sediment routing, water quality	Upland land use practices, erosion, loss of water storage capacity	Abundance, productivity	All	
Apply BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Subbasin-wide	Altered hydrology, sediment routing	Forestry, roads, overgrazing, Agricultural practices, noxious weeds	Abundance, productivity	All	Upland management practices affect the hydrologic function of the watershed by causing rapid runoff rather than infiltration. BMP's should be implemented to insure that the watershed functions to its potential, given the anthropogenic influence in the watershed.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove junipers	SWCD's, NRCS	Ongoing	Uplands	Immediate	0-20 years	Uncertain, control must be followed by appropriate

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
						management strategies
Restore native upland plants	USFS, BLM, NRCS, SWCD's, watershed councils, CTWSRO, BIA	Ongoing	High dispersal downstream	Juniper control can be quick, other actions such as control of invasive plants may take 20 years or more	0-20 years	Uncertain
Upgrade or remove problem forest roads	CTWSRO, USFS, ODOT, ODF	Ongoing	High dispersal downstream	Long term	Immediate for sediment, other parameters 5-15 yrs	Likely
Promote reforestation and fuels management	CTWSRO, USFS, watershed councils, SWCD's, counties	Ongoing	Forestlands	Long term	0-10 yrs	Likely
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to minimize unnatural rates of erosion	SWCD, USFS, ODA, ODF, BLM, CTWSRO, watershed councils, NRCS, private landowners	Ongoing	High dispersal downstream	Intermediate	5-15 years	Likely
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	SWCD, USFS, ODA, CTUIR, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of water quality management plans and other plans.	0-20 years, depending on treatments applied	Uncertain, dependent on voluntary landowner participation

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS,SWCD, Private Landowners	CRP, CREP, Environmental Quality Incentive Program (EQUIP)	Private upland and riparian lands	Uncertain	An effective program for both upland and riparian protection, but could be expanded to additional private lands. Continued implementation of program dependent on funding. See State of Oregon programmatic review -- Appendix F for SWCD.
SWCD's	Voluntary Watershed Restoration	Private agricultural lands		Dependent on funding, and landowner interest. See State of Oregon programmatic review -- Appendix F.
BLM	Various projects related to rangeland improvements in uplands.	BLM lands	Uncertain	Effective programs that could be expanded to additional lands.
CTWSRO	IRMP	Reservation Lands	Likely	Adaptive plan could be expanded.
USFS	Stream Restoration Program (PACFISH), Vegetation Management Programs, Range Management Programs	USFS forest lands	Uncertain	Effectiveness of program unproven. May need expanded monitoring. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
Many benefits to steelhead have been seen in upland and riparian management plans since the 1987 Farm Bill. CRP in uplands and riparian protection provide short-term benefits, however longer periods are required to restore stream channel and habitat. Habitat benefits of CRP enrollments are dependent upon agreements between participating agencies and landowners. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize active watershed restoration for this population, and helps deploy limited active watershed restoration funding where it is most needed. Implementation of PACFISH standards and guides for Forest and BLM programs, in conjunction with Forest Plan Management Area allocations, has been highly successful for passive upland restoration over most of this population's area.

9.3.5 Habitat Strategies and Actions for Lower Mainstem John Day River Steelhead Population

Primary limiting factors: degraded channel structure and complexity (habitat quantity and diversity), altered sediment routing, water temperature, and altered hydrology. Impaired fish passage is also a high priority limiting factor in Bridge, Butte, Kahler, Muddy, Rock, and Thirtymile creeks.

Primary threats: agricultural and grazing practices, removal of overstory trees and bank vegetation from the riparian corridor, water withdrawals, wetland draining and conversion, and stream channelization and diking.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition or conservation easements	Mountain Cr. (2); Pine Cr. (1); Cottonwood Cr. (1); Bridge Cr (1). Reaches are either designated roadless areas, Wilderness Study Areas, or designated Wilderness Areas within the watershed. John Day River, Parrish Cr to Tumwater Falls (a Wild and Scenic River) (2); Butte Cr, lower 8 miles (2)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	Many threats including livestock overgrazing of riparian area, channelization, stream bank armoring, agricultural practices (fertilizers, herbicides, sediments, changes in plant communities), water withdrawals, loss of beaver dams	Abundance, productivity	All	Protection of high quality habitats is the most cost effective way of ensuring fish have good quality habitat. It is much less expensive over the long term to protect high quality habitat than it is to degrade the habitat and then try to restore it. Many objectives are likely to be met just by habitat protection and the associated natural recovery of upland and/or riparian areas. Land acquisitions, easements, and cooperative agreements may also facilitate the implementation of active restoration projects.
Adopt and manage Cooperative Agreements	For those stream reaches already under either CREP or ODFW cooperative agreements on Alder (2), Pine Hollow (1), Rock (Gilliam Co) (2), Mountain (1), Cottonwood (1), Squaw (2) and Butte (1) crs	Same as above	Same as above	Abundance, productivity	All	
Designate additional wilderness and wild and scenic status	Convert Wilderness Study Areas on public lands to Wilderness at Spring Basin (1), Pat's Cabin (1), Sutton Mountain (2), North Pole Ridge (2), Thirtymile (1), and Lower John Day mainstem (2)	Same as above	Land use practices	Abundance, productivity	All	
Special management designations in forest and BLM	Bridge Cr, adjacent to the Sutton Mt. WSA (1), and on Ochoco National Forest (2)	Same as above	Livestock grazing of riparian area, changes in	Abundance, productivity	All	These special designations include Riparian Habitat Conservation

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
plans			plant communities			Areas and Anadromous Fish Emphasis
Protect access to key habitats	None identified at this time, although ODFW periodically reviews proposals that could block passage into spawning and rearing habitat.	Passage barriers, altered hydrology, channel structure		Abundance, productivity, distribution	All	Thoroughly review projects that may block fish passage. Current ODFW policy is to grant exemptions from fish passage requirements only if mitigation meets or exceeds the loss of habitat. Exemptions must be approved by the Fish and Wildlife Commission
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	Population-wide	All	Same as above	Abundance, productivity	All	
Conduct outreach to resource users and managers	Population-wide	All				

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements	CTUIR, TNC, RMEF, John Day Basin Trust, SWCDs	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5-15 years with passive restoration approaches	High, based on previous cooperative agreements
Adopt and manage Cooperative Agreements	ODFW, SWCDs, FSA	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Agreements are for 10-15 years	Immediate	High, although not in perpetuity
Designate additional wilderness and wild and scenic status	USFS, Oregon State Parks	Ongoing as identified	Water quality and flow improvements would have high dispersal downstream, stream corridor and function improvements confined to the specific site	unknown	5-15 years	Unknown, subject to availability of areas that meet criteria
Special management designations in forest and BLM plans	USFS, BLM	Ongoing as identified	Same as above	Many complete, potentially subject to change in Forest Plan revisions	Immediate	High, although subject to change from Forest Plan or mgmt plan revision
Protect access to key habitats	None identified at this time, although ODFW periodically reviews proposals that could block passage into spawning and rearing habitat.					

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	NRCS, SWCDs, USFS, ODFW, ODF, DSL, BLM, ODOT, CTWSRO, ODA, FSA, private landowners	ongoing	Population-wide	Long term	5-15 years	High
Conduct outreach to resource users and managers	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	ongoing	Population-wide	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS and BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management Area designations, PACFISH	Bridge Cr, Cottonwood Cr, Pat's Cabin, North Pole Ridge, Lower John Day, Spring Basin, Thirtymile, and Sutton Mountain for Wilderness, all streams within National Forest and BLM lands for PACFISH	Yes	See USFS/BLM Program Sufficiency Assessment—Appendix E. Additional areas may be considered for addition to special management area protected status on FS lands. BLM has no opportunities to expand any of these programs.
ODFW	Cooperative Agreements	Alder, Cottonwood, Squaw and Mountain crs	Uncertain	The agreements are for only 10-15 years and need extended.
FSA	CREP	Rock, Pinehollow, and Butte crs	Uncertain	The agreements are for only 10 or 15 years and need extended.
NGOs	Lease or purchase of lands or instream water rights		Yes	Important to secure critical habitat and/or water rights.
ODA	Agricultural Water Quality Management Program	The entire lower subbasin		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Pine Cr	Likely	Could expand program.
ODF	Oregon Forest Practices Act	All private and state owned lands		See State of Oregon programmatic review -- Appendix F.
Local Government	City and County Planning and Zoning	Private land and population-wide	Varies by county, Grant County currently has 100' riparian setbacks.	Although large scale development is not presently occurring throughout the John Day subbasin, it will likely occur within the next 30 years.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The John Day River has 248.6 miles designated as Federal Wild and Scenic River and 317 miles designated as State Wild and Scenic, including the John Day River from Tumwater Falls (RM 10) to Service Cr (RM 157). State designated reaches include the John Day mainstem from Tumwater Falls (RM 10) to Parrish Cr (RM 170). Although wild and scenic designation does not preclude development, it requires development to be consistent with protecting the Outstandingly Remarkable Values (ORV's) for which the river was designated, requires review of any activity that may affect ORV's within the ¼ mile river corridor, and protects the free flowing condition of the river. Designation as W&S essentially precludes construction of any major dam. A Management Plan adopted by BLM and Oregon State Parks Department in 2001 for the designated rivers segments identifies specific management actions including development of livestock grazing management plans for each allotment. Grazing management plans for most of the allotments within the corridor are complete; all BLM grazing plans are complete.

Existing forest plans include special management designations for RHCAs. Adding additional wilderness areas and wild and scenic river segments would require designation by Congress. The forest plans and BLM plans have been amended by PACFISH, which requires 300-foot buffers on any fish bearing stream for tree removal, as well as specific guidelines for livestock grazing and riparian vegetation use. Compliance with the 300-foot buffer for timber harvest operations has been very good. In areas where trees were harvested before the rules went into effect, it will take decades for them to grow big enough to function as large wood and contribute to LWD. Forest practices rules for private and state owned forest lands have guidelines for protection of riparian function, although they are not nearly as restrictive as those on federal lands.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.
Designating additional RMAs or adding to the current restrictions within RHCAs will be revisited during the Forest Plan Revision process that is currently underway. Cooperative and conservation agreements on private land are tools for protecting high quality habitats. ODFW has used cooperative agreements over the last 21 years to protect riparian corridors that have been fenced to exclude livestock grazing. Unfortunately those agreements are for only 15 years and there have not been funds or personnel needed to extend them for longer time periods. CTWSRO owns mitigation property near Clarno on the mainstem John Day River. It encompasses 33,557-acres and includes approximately 20 miles of steelhead spawning and rearing habitat. All CTWSRO properties will be in conservation status perpetually. FSA programs that protect riparian areas and upland watersheds include the CRP, which pays landowners not to farm highly erodible soils, and the CREP program, which pays landowners for setting riparian corridors aside from grazing and farming. The long term effectiveness of both programs is limited by the relatively short duration of the contracts which ranges from 10 to 15 years. NRCS programs that protect riparian areas and upland watersheds include the Conservation Reserve Program (CRP) and the Conservation Reserve Enhancement Program (CREP). The CRP program pays landowners not to farm highly erodible soils and the CREP program pays landowners for setting riparian corridors aside from grazing and farming. The long term effectiveness of both programs is limited by the relatively short duration of the contracts which ranges from 10 to 15 years.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Remove or minimize use of push up dams	Rock (1); Upper Rock (1), Middle Rock (1), Lone Rock (1), Thirtymile (1), Butte (1), Big Muddy (2), and Rock/Mountain crs (2)	Impaired fish passage	Push up dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Push up irrigation dams are located throughout the entire subbasin and are common in the Rock/Mountain Cr drainages. Annual maintenance and construction of push up dams contributes to onsite and downstream channel stability, loss of pools and other structure, and increased sediment loads.
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	Rock (1), Upper Rock (1), Middle Rock (1), Lone Rock (1), Thirtymile (1), Butte (1), Kahler (1), Big Muddy (2), and Rock/Mountain crs (2)	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Concrete diversions, in-channel stock ponds, and road culverts are located throughout the entire subbasin. Concrete structures are located primarily in the Rock Cr (Lower John Day) drainage although there are a number of structures scattered throughout other parts of the subbasin, including Cherry Cr. Passage problems at culverts are widespread throughout all subbasins.
Provide screening at 100% of irrigation diversions	Rock Cr (Gilliam Co.) (1), Keeton Cr. (Wheeler Co.) (2), Bridge Cr. (Wheeler Co.) (1), Lower John Day mainstem pumping sites (2)	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry	Adequately screened diversions provide immediate benefits.
Replace screens that do not meet criteria	Rock Cr (Gilliam Co.) (1), Keeton Cr. (Wheeler Co.) (2), Bridge Cr. (Wheeler Co.) (1), Lower John Day mainstem pumping sites (2)	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry	Screening of irrigation diversions began in 1950s and most were screened by mid-1970s. Many screens now need to be replaced to address new criteria to reduce entrainment of emergent fry and bull trout.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove or minimize use of push up dams	SWCD	Ongoing	Provide access to upstream habitat	Ongoing, but all push up dams not expected to be corrected for at least 15 years	Immediate	High, if comply with fish passage design criteria
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	USFS, watershed councils, SWCDs, ODOT	Ongoing	Access to upstream habitat	Ongoing, replacing all culverts blocking fish passage expected to take 50 years	Immediate	High, if comply with fish passage design criteria. BLM has no culvert barriers to adult fish. Monitoring needed to determine if upstream passage for juveniles is an issue.
Provide screening at 100% of irrigation diversions	ODFW, SWCDs	Ongoing	At point of diversion	Approximately 16 diversions need to be screened, should take 5-10 years	Immediate	High if comply with fish passage design criteria
Replace screens that do not meet criteria	ODFW	Ongoing	At point of diversion	Approximately 10 screens need to be replaced, should take 5-10 years	Immediate	High if comply with fish passage design criteria

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Soil and Water Conservation Districts	Irrigation dam improvements, culvert replacement or retrofits	Unscreened or poorly screened diversions throughout population		The Soil and Water Districts are constrained by the construction window of opportunity. The counties could expand the program but are constrained by funding and personnel. See State of Oregon programmatic review -- Appendix F.
ODFW	Fish Passage/Screening state program and federally funded	Unscreened or poorly screened diversions throughout population	No	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding.
USFS	Culvert replacement	Throughout population on Federal land	Uncertain	Program progressing slowly, culverts replaced are sufficient. BLM has no culvert barriers to adult fish. Monitoring needed to determine if upstream passage for juveniles is an issue.
Watershed Councils	Road Crossing Passage improvements, passage improvements	Throughout population	Uncertain	Programs need additional resources.
ODOT	Culvert replacement or retrofit	Throughout population		See State of Oregon programmatic review -- Appendix F.
BOR	John Day Basin Program		Yes	
CTWSRO	John Day Basin Program		No	The tribe contracts with Soil and Water Districts to assist with consultation, permits, and monitoring program.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The mainstem passage problems for the Lower Mainstem John Day population have been addressed, but there are many tributaries where adult passage is blocked and more areas where juvenile passage problems occur. Irrigation dams, stock ponds, and road culverts are the primary causes of passage issues. Soil and Water Districts are correcting passage at irrigation diversions and improperly installed culverts, but are constrained by funding and by personnel needed for construction oversight. An inventory of road crossings on state and county roads in 1999 indicated 23 culverts on state owned roads and 43 culverts on county owned roads did not meet fish passage criteria in the Lower Mainstem John Day River population. Appendix G presents an inventory of known passage problems associated with culverts on state, county, or Federal roads. Some of those culverts have been replaced with structures that do meet the fish passage criteria, but much work remains. Watershed councils and ODOT, who are the principal entities working on culverts

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.
are constrained primarily by funding. An inventory of road crossings on federal lands indicates juvenile passage problems are pervasive, particularly on National Forests, with approximately 22 culverts not meeting passage criteria on National Forest land. The US Forest Service and BLM are constrained primarily by funding and the personnel needed for NEPA analysis. At the current rate of culvert replacements, it will take over 50 years to correct all passage problems on National Forests in all five John Day populations. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Another constraint is that existing state laws do not require passage improvements at existing barriers unless there is a major change in the structure, such as reconstruction or significant modifications, so landowner cooperation is critical for improving passage throughout the subbasin.
US Bureau of Reclamation is required in the Columbia River Biological Opinion to identify and assist with passage improvement design and flow restoration.
Currently, the ODFW Fish Passage and Screening program replaces about 20 irrigation diversion screens per year in the John Day subbasin. With over 120 diversions in the John Day subbasin that either do not meet current screening criteria or are unscreened, it would take at least 6 years to replace them all. Of the 120 diversions, 26 need screens or screens replaced in this population. Currently, highest priority is given to diversions that are unscreened with lower priority given to diversions that have screens, but do not meet the criteria. The program is constrained primarily by funding and personnel. Current law does not require water users to screen diversions less than 30 cubic feet per second and virtually all diversions in the John Day are less than 30 cfs, so landowner cooperation is essential to success of the program.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Rock (2), Upper Rock (1), Middle Rock (2), Lone Rock (1), Thirtymile (1), Butte (1), Bridge (1) Kahler (1), Mountain (1), Pinehollow (1), Grass Valley (2), and Hay (2) crs	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily eggs, fry and 0+	
Restore wet meadows	Thirtymile (1), Butte (1), Bridge (1), Kahler (1), Mountain (1), Rock (2), Upper Rock (2), Middle Rock (2), Lone Rock (2), Pinehollow (2), Grass Valley (2), and Hay (2) crs	Degraded floodplain, altered hydrology	Removal of wetlands	Abundance, productivity	Primarily eggs, fry and 0+	
Reconnect side channels and off-channel habitats to stream channels	Upper Rock (1), Rock (2), Middle Rock (2), Lone Rock (2), Thirtymile (2), Butte (1), Bridge (1), Kahler (2), Mountain (1), Pinehollow (2), Grass Valley (2), and Hay (2) crs	Degraded floodplain, altered hydrology	Removal of side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily eggs, fry and 0+	There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	Rock (2), Upper Rock (1), Middle Rock (2), Lone Rock (1), Thirtymile (2), Butte (1), Bridge (1), Kahler (1), Mountain (1), Pinehollow (1), Grass Valley (2), and Hay (2) crs	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity	Primarily eggs, fry and 0+	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain habitats	ODFW, watershed council, SWCD, USFS, BLM	Ongoing	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Restore wet meadows	TNC, USFS, CTWSRO	Ongoing and	Benefits of improved channel	Intermediate	5-15 years	Moderate

Strategy 3. Maintain and restore floodplain connectivity and function.						
		planned	morphology localized, improved water table and resulting increased streamflow and lower water temperatures have high dispersal downstream			
Reconnect side channels and off-channel habitats to stream channels	ODFW, watershed council, SWCD, USFS, BLM, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, because of widespread need	5-15 years, depending upon frequency and duration of channel altering flows	Moderate, depending upon how extensive the project is and frequency and duration of channel altering flows
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	ODFW, CTWSRO, USFS, BLM	ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, due to acceptance by landowners and widespread need	Within 5 years once the dams are built	Moderate-high, dependent upon acceptance by landowners

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	None completed to date	No	If specific needs cannot be addressed by passive restoration techniques, program underfunded
USFS, BLM	Stream enhancement program	Population-wide on Federal land, only when specifically identified that passive restoration is not working	Likely	The USFS/BLM preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
Watershed Councils	Watershed restoration	Population-wide	Dependent upon need and funding	Only if specific needs cannot be addressed by passive restoration techniques
Soil and Water Conservation Districts	Watershed restoration	Population-wide		See State of Oregon programmatic review -- Appendix F.
Nature Conservancy and other NGOs	Restoration projects	Population-wide	Uncertain	Yes
ODA	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.
CTWSRO, CTUIR	Watershed restoration	Pine Cr	Uncertain	Program could be expanded.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Rock (1), Upper Rock (2), Middle Rock (1),	Degraded channel	Stream channelization,	Abundance,	Primarily	Passive restoration techniques, such as

	Lone Rock (2), Thirtymile (2), Butte (2), Bridge (2), Kahler (2), Mountain (2), Pinehollow (1), Grass Valley (2), and Hay (2) crs	structure and complexity, habitat diversity, sediment routing, water temperature, flows	bank armoring, large wood removal, beaver removal, removal of riparian vegetation, livestock overgrazing in riparian areas	productivity	eggs, fry and 0+	riparian fencing, are the preferred method for improving channel structure and stability. More active restoration techniques may be appropriate in these reaches.
Place stable wood and other large organic debris in streambeds and in floodplains	Rock (2), Upper Rock (1), Middle Rock (2), Lone Rock (2), Thirtymile (1), Butte (1), Bridge (1), Kahler (1), Mountain (1), Pinehollow (2), Grass Valley (2), and Hay (2) crs	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal channelization	Abundance, productivity	Primarily eggs, fry and 0+	More active restoration techniques, such as rootwad placement or channel reconfiguration, may be appropriate in these reaches.
Stabilize streambanks	Rock (1), Upper Rock (2), Middle Rock (1), Lone Rock (2), Thirtymile (1), Butte (2), Bridge (2), Kahler (2), Mountain (2), Pinehollow (1), Grass Valley (2), and Hay (1) crs	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily eggs, fry and 0+	Some bank erosion is inevitable and beneficial. However, where erosion is actively taking place due to unnatural processes, stabilization may be needed to reduce fine sediments

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, USFS, BLM, watershed councils	Ongoing and planned	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Place stable wood and other large organic debris in streambeds and in floodplains	ODFW, USFS, watershed councils, BLM, SWCDs	As needed	For the immediate stream reach	Once identified, short term	Immediate	High
Stabilize streambanks	ODFW, USFS, watershed councils, BLM, SWCDs	Ongoing	For the treated stream reach, physical benefits dispersed downstream	Passive stabilization techniques are referred and take longer to implement	With passive restoration the response may take 15 years	Moderate to high, depending upon the extent of the treatments

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Only used where passive restoration has not been successful. To date, no structural work has been identified	Uncertain	If specific needs cannot be addressed by passive restoration techniques then program needs expansion.
USFS, BLM	Stream enhancement program	Only used where passive restoration has not been successful. To date, no structural work has been identified	Uncertain	The USFS/BLM preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. May need expansion in some areas. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
Watershed Councils	Watershed restoration	Only used where passive restoration has not been successful. To date, no structural work has been identified	Dependent upon need and funding	If specific needs cannot be addressed by passive restoration techniques needs expansion.
Soil and Water Conservation Districts	Watershed restoration	Only used where passive restoration has not been successful. To date, no structural work has been identified		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Only used where passive restoration has not been successful. To date, no structural work has been identified	Dependent upon need and funding	If specific needs cannot be addressed by passive restoration techniques needs expansion.

NGOs	Watershed restoration	Only used where passive restoration has not been successful. To date, no structural work has been identified	Dependent upon need and funding	If specific needs cannot be addressed by passive restoration techniques needs expansion.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Instream activities have not been identified as a high priority by the recovery planning team or the management action planning team except when identified as a need for specific sites. The planning team prefers that more passive approaches, such as riparian and upland improvements be emphasized. Typically, instream activities that would improve floodplain function and channel migration processes would include placement of rootwads, whole trees, or boulder clusters to improved habitat complexity and habitat diversity where those parameters are deficient and not expected to improve with passive restoration. Another structural activity would be to construct boulder or log weirs to raise the water table, but only where a passive approach has not worked. Currently little instream structure placement has been identified for this population. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategic Actions and Impacts on Limiting Factors, Threats, and Population

Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	Lower John Day River mainstem below Cottonwood Bridge and above Service Cr (2); Rock Cr (2); Upper Rock (2); Middle Rock (2); Lone Rock (1); MaSAs (Gilliam Co) (2); Grass Valley Canyon (2); some reaches of Mountain Cr (Wheeler Co) (1); portions of Parrish Cr (1), Cherry Cr (1); some reaches of Kahler Cr (1), Ferry Cr (2), upper Hay Cr (2); portions of Bridge Cr (1), Thirtymile Cr (1), Horseshoe Cr (2), Johnson Cr(2), Butte Cr (1), Franks Cr (2), and upper reaches of Pine Hollow Canyon Cr (1)	Degraded riparian area, channel structure and complexity, floodplain degradation, altered hydrology, sediment, water quality	Livestock overgrazing of riparian area, channelization, stream bank armoring, cutting of trees in riparian areas, changes in plant communities (including invasive plants), loss of beaver dams	Abundance, productivity	Primarily fry and 0+	Primary methods of riparian enhancement include riparian corridor fences to exclude livestock, changes in grazing management that promote riparian recovery, and planting of native shrubs.
Develop grazing strategies that promote riparian recovery	Lower John Day River mainstem below Cottonwood Bridge and above Service Cr (2); Rock Cr (2), Upper Rock (1), Middle Rock (2), Lone Rock (1); MaSAs (Gilliam Co) (2), Grass Valley Canyon (2); some reaches of Mountain Cr (Wheeler Co) (1); portions of Parrish Cr (1), Cherry Cr (1); some reaches of Kahler Cr (1), Ferry Cr (2), upper Hay Cr (2); portions of Bridge Cr (1), Thirtymile Cr (1), Horseshoe Cr (2), Johnson Cr (2), portions of Butte Cr (1), Franks Cr (2), and upper reaches of Pine Hollow Canyon Cr (1)	Degraded riparian area, channel structure and complexity, floodplain degradation, altered hydrology, sediment, water quality	Livestock overgrazing of riparian area	Abundance, productivity	Primarily fry and 0+	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities including vegetative planting	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high	Long term because of widespread need	5-15 years, (see above)	High, based upon experience with existing grazing management

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
			dispersal downstream from site			and riparian recovery projects
Develop grazing strategies that promote riparian recovery	NRCS, AFS, USFS, BLM, SWCDs, ODFW, Watershed Councils, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, depending upon grazing plan adopted. Riparian corridor fencing and removal of riparian grazing has the fastest recovery rate.	High, based upon experience with existing grazing management and riparian recovery projects

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Alder, Squaw, Cottonwood, and Mountain crs	No	Program could be expanded.
SWCDs	Upland improvements, riparian improvements	Service, lower Rock, Lone Rock, Pinehollow, Grass Valley, Hay, Alder, Butte	Yes in some areas, no in others	Expansion would approve effectiveness.
Watershed Councils	Upland improvements, riparian improvements	Service, lower Rock, Lone Rock, Pinehollow, Grass Valley, Hay, Alder, Butte	No	Expansion in scope needed.
USFS, BLM	Upland improvements, riparian improvements	Lower John Day mainstem from Kimberly to Tumwater Falls, Cottonwood, Bridge, Thirtymile, Ferry, Hay, Squaw	Likely	Expansion in scope needed. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
NRCS	Upland improvements, riparian improvements	Pinehollow, Grass Valley, Ferry, Hay, Thirtymile, Butte	Yes	Program currently meeting objectives.
ODA	Agricultural Water Quality Management Program	All		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Pine Cr	Uncertain	Needs expansion.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

In the last 20+ years ODFW, Watershed Councils, NRCS and Soil and Water Districts have implemented hundreds of miles of riparian improvements on private lands, primarily through construction of riparian corridor fences that exclude livestock grazing and development of off channel watering devices. Public land managers have implemented PACFISH standards for protection and restoration of USFS and BLM lands. Even though hundreds of miles of riparian improvements have been completed there are many more miles of stream occupied by steelhead within the Lower Mainstem John Day population that need improvement. At the current rate of implementation it could take 50 years to complete restoration actions. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Bank stabilization using some rock is still infrequently occurring after high water events in the lower John Day River, primarily along irrigated pastures and on Rock Cr (Gilliam County). These bank stabilization projects have historically relied on riprap and large rock, however in recent years the high economic and ecological cost of bank armoring with riprap and of channelization has been recognized, so the emphasis has shifted toward a more passive approach for stabilization, primarily through riparian vegetation improvements. Overgrazing of riparian areas by livestock continues in some reaches; however it is not as widespread as historically. Interest by private landowners and public land managers in riparian improvement remains high.

Other projects that have been well accepted and will improve riparian condition are restoring historical cover types by removing juniper, reintroducing fire, enrollment into CREP, and control of invasive/noxious plants. Primary constraints on implementing additional projects for more riparian improvements are funding and personnel needed for planning, promotion, education of landowners, and implementation.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters	Life Stages	Discussion

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
				Addressed	Affected	
Implement agricultural water conservation measures	Rock (1), Bridge (1), Butte (2), Cherry (2), Big Muddy (2), Cottonwood (2), Rock/Mountain (1), Alder (2), lower Parrish (1), and Kahler (1)crs	Altered hydrology, low flows, high temperatures	Water withdrawals, land conversion on uplands, road network	Abundance, productivity	Eggs, fry and 0+	Rock, Bridge, Butte, Cherry, Big Muddy, Cottonwood, Rock/Mountain, Alder, lower Parrish, and Kahler crs are all affected by irrigation withdrawals.
Improve irrigation conveyance and efficiency	Rock (1), Bridge (1), Butte (2), Cherry (2), Big Muddy (2), Cottonwood (2), Rock/Mountain (1), Alder (2), lower Parrish (1), and Kahler (1) crs.	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Eggs, fry and 0+	Rock Cr is intermittent for the lower 29 miles due to extensive pumping for irrigation and several of its tributaries are dry during summer months in lower reaches.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	Grass Valley Canyon (2), Pinehollow Canyon (1), Rock (1), Bridge (1), Butte (1), Cherry (1), Big Muddy (2), Cottonwood (1), Rock/Mountain (1), Alder (2), Johnson (2), Horseshoe (2), Ferry (2), Hay (1), Thirtymile (1), Service (2), Parrish (1), and Kahler (1) crs	Low flows, high temperatures	Channel incision, loss of water table	Abundance, productivity	Fry and 0+	
Lease or acquire water rights and convert to instream water rights	Rock (1), Bridge (2), Butte (2), Cherry (2), Big Muddy (2), Cottonwood (2), Rock/Mountain (1), Alder (2), lower Parrish (1), and Kahler (1)crs	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Eggs, fry and 0+	
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Eggs, fry and 0+	Annual fluctuations in flow levels are intensified by irrigation withdrawals.
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Altered hydrology, low flows, high temperatures, impaired natural functions and processes on uplands, floodplains, riparian areas	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Eggs, fry and 0+	Changes in the upland plant community due to fire suppression, invasive plants, and conversion of bunch grass prairies to wheat fields have resulted in lower precipitation infiltration rates, which results in higher peak flows and lower low flows. Some tributaries are now dry where they join the John Day River. Removal of large wood and channelizing streams also increases water velocities and reduces the ability of the stream to hold water for gradual release. Restoring watershed function in Pinehollow Canyon will likely result in longer duration of surface flows.
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Implement agricultural water conservation measures.	SWCD, OWRD, watershed councils, NRCS	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights.
Improve irrigation conveyance and efficiency.	SWCD, OWEB, OWRD, watershed councils, NRCS, landowners	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	SWCD, ODFW, CTWSRO, USFS	Ongoing	High dispersal downstream	Long term	Immediate increase in instream flow, 5-15 years for full functional role	High
Lease or acquire water rights and convert to instream water rights.	OWRD, FSA, OWEB, Oregon Water Trust, others	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and highly dependent upon landowner willingness to lease.	Immediate	High, if the leased water is protected from being appropriated to a downstream user in areas with instream water rights. FSA pays higher rates for CREP enrollment when water rights are leased for instream use.
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion downstream to mouth of John Day River	Long term, dependent upon OWRD enforcing the requirement to measure water usage	Immediate	High if water user reporting requirement and installation of measuring devices on diversions is implemented.
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD, USFS, OWRD, OWEB, ODFW, CTWSRO, landowners	Ongoing	Population-wide	Intermediate	Up to 15 years	High
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate
Status of Existing Programs through which Actions are Implemented						
Agency/Organization	**Program Name**		**Geographic Locations**	**Sufficient* (yes, likely, uncertain, no)**	**Sufficiency Rationale**	
ODFW	BPA Habitat Program, riparian improvements		Alder, Cottonwood, Squaw, Rock/Mountain	No	Yes	

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.				
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Population-wide		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust, BOR	Leasing and Purchase of Water Rights	Lower John Day River near Twickenham, Pine Cr	Uncertain	Dependent on availability and funding.
Soil and Water Conservation Districts	Improve irrigation efficiency, upland improvements, riparian improvements	Butte, Pinehollow, Lower Mainstem John Day River below Service Cr		Could be expanded in some areas. See State of Oregon programmatic review -- Appendix F.
Watershed Councils	Upland improvements, riparian improvements	Most of Gilliam, Sherman, and parts of Wasco counties in dryland wheat country, juniper treatments in Wheeler County	No	Wheat field terracing, conversion to no-till, construction of sediment retention basins—could all be expanded in rate of implementation.
NRCS	Upland improvements, riparian improvements	Most of Gilliam, Sherman, and parts of Wasco counties in dryland wheat country, juniper treatments in Wheeler County	No	Wheat field terracing, conversion to no-till, construction of sediment retention basins, could all be expanded in rate of implementation.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Many landowners have converted from flood to sprinkler or gated pipe irrigation, which makes more efficient use of the water and grows more palatable forage, but there has not been an effective mechanism to protect saved water from being used by another irrigator downstream. Water measuring devices are just beginning to be required on irrigation withdrawals and while progress is being made there is considerable resistance from irrigators. Extensive work by Watershed Councils and NRCS in the Lower John Day has concentrated on preventing erosion of valuable topsoil by terracing wheat fields, building small sediment retention basins, enrollment of highly erodible soils into the CRP program, and using no-till planting techniques, all of which increases precipitation infiltration rates and reduces the rate of runoff. Other projects that will improve flow are restoring historical cover types by removing juniper, reintroducing fire, enrollment into CRP, and control of invasive/noxious plants. Primary constraints on implementing additional projects are funding, instream water rights that are junior to most irrigation rights, and water laws that sometimes conflict with conservation practices. Approximately 76 miles of stream in the lower John Day River are protected with either existing or pending instream water rights. The instream water rights do not preclude further appropriation of water until flows in the affected reach drop down to the instream water rights as adopted by OWRD. Voluntary efforts restored 25.5 cfs instream in 2006. US Bureau of Reclamation, as required in the Columbia River Biological Opinion, is required to identify and assist with passage improvement design and flow restoration. They have partnered with Oregon Water Trust on several water leases with one recent permanent acquisition of 10 cfs in the Middle Fork that will be left instream after July 20.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Increase riparian shading	Thirtymile (1), Rock (2), Butte (1), Service (2), Kahler (1), Parrish (1), Upper Rock (1), and Lone Rock (1) crs; upper Butte (1), Cottonwood (1), Squaw (2), Horseshoe (2), Johnson (2), Bridge (2), Ferry (2), Pinehollow (1), Grass Valley (2), Mountain (1), Kahler (1), Parrish (1), Cherry (1), Hay (1), Alder(1), and Shoefly (2)crs	High water temperatures	Degraded riparian forests	Abundance, productivity	Eggs, fry, 0+, adults	Elevated water temperature is the most pervasive water quality problem for the Lower John Day River population, with 13 stream reaches listed as water quality limited. Additional reaches would probably be listed if water temperature data were available.
Reduce chemical pollution inputs	None currently identified	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity	Eggs, fry, 0+, adults	

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Apply BMPs to animal feeding operations	Lower Rock Cr (1)	Degraded water quality	Animal feed operations	Abundance, productivity	Eggs, fry, 0+, adults	
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Degraded upland processes, floodplains, riparian areas, altered hydrology, altered sediment routing	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Eggs, fry, 0+, adults	Using efficient irrigation methods reduces the amount of surface water returning to the stream, and should result in fewer nutrients from pastures reaching the John Day River. Reducing nutrient loads will contribute to increased water quality by reducing biological oxygen demand and algae blooms.
Continue TMDL monitoring	Population-wide	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	Eggs, fry, 0+, adults	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Increase riparian shading	ODFW, Watershed Councils, SWCDs, USFS, BLM	Ongoing	water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years	High
Reduce chemical pollution inputs	ODEQ, others	Ongoing		Ongoing	Reduce chemical pollution immediately	High
Apply BMPs to animal feeding operations	ODA	Ongoing	Water quality improvement would have high dispersal downstream	Some treatments could be done immediately. There are few animal feeding operations within the subbasin, only one of which has been identified as a problem	5-15 years	High, once a treatment has been agreed upon
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD	Ongoing	Subbasin-wide, high dispersal downstream	Intermediate	Up to 15 years	High
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA	CREP, CRP	Gilliam, Sherman and portions of Wasco counties for CRP, Butte, lower Rock, Pinehollow, and Grass Valley tributaries for CREP	No	Program needs expansion, effective where applied.
ODA	Confined animal feeding operations (CAFO), Agricultural Water Quality Management Program	Rock Cr		See State of Oregon programmatic review -- Appendix F.
ODEQ, ODA, SWCD, USFS	Sedimentation Monitoring (TMDL Development and Implementation)	Population-wide		See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment—Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
Extensive grain fields in the Lower John Day River area have contributed to relatively high sediment loads in the lower river and tributaries. NRCS and FSA programs in this area (primarily CRP and terracing)) have been used extensively by landowners on the most erodible soils, but the removal of perennial grasses to plant annual crops still contributes unnatural levels of sediment. Other sources of sediment include relatively high road densities on forested lands. Low streamflows during the hottest part of the year exacerbate the already warm water temperatures. Opportunities for increasing streamflow through leasing of water rights, which often results in cooler water over a longer stream reach, are being pursued by Oregon Water Trust and US Bureau of Reclamation. Constraints for future projects include acceptance by landowners and a secure, long term funding source. ODA's Agricultural Water Quality Management Program is designed to prevent and control water pollution from agricultural activities and soil erosion on non-Federal and non-Tribal Trust or Reservation lands. ODA relies on voluntary measures to protect water quality, but also enforces pollution and streamside vegetation requirements. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Reducing water temperatures through the use of improved riparian vegetation and more efficient methods of irrigation may take several years to provide measurable results. Many projects that improve water quality by reducing irrigation return water have been completed.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Continue to promote no-till farming and other seeding techniques that reduce erosion where site conditions are suitable	Rock (1), Grass Valley (1), Ferry(1), Thirtymile (2), Pinehollow (2), Jackknife (2) crs,	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices, loss of water storage capacity	Productivity	Eggs, fry, and 0+	No till seeding has been used in much of Sherman and Gilliam counties, however, other economically viable alternatives that reduce erosion are desirable.
Restore native upland plant communities	Thirtymile (1), Rock (2), Butte (1), Service (2) , Kahler (2), Parrish (2), Upper Rock (2), and Lone Rock (1) crs, Pinehollow (1), Ferry(1), Horseshoe (2), Service (2), Squaw (2), Bridge (1),	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices, loss of water storage capacity	Productivity	Eggs, fry, and 0+	Upland improvements such as restoring native plant communities and controlling invasive weed species will improve precipitation infiltration rates and ultimately improve watershed health, including the hydrograph.
Upgrade or remove problem forest roads	Thirtymile (1), Upper Rock (2), Alder (2), Parrish (2)	Altered hydrology, sediment routing	Road network	Productivity	Eggs, fry, and 0+	
Initiate upland improvement demonstration projects	Thirtymile (2), Rock (2), Butte (2), Service (1), Kahler (1), Parrish (1), Upper Rock (1), and Lone Rock (2) crs	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Productivity	Eggs, fry, and 0+	
Manage vegetation, including juniper removal	Thirtymile (2), Rock (2), Butte (1), Service (2), Kahler (1), Parrish (1), Upper Rock (2), and Lone Rock (2) crs	Altered hydrology, sediment routing	Invasive plants	Productivity	Eggs, fry, and 0+	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Thirtymile (1), Rock (2), Butte (1), Service (2), Kahler (2), Parrish (1), Upper Rock (1), and Lone Rock (2) crs	Altered hydrology, sediment routing	Upland land use practices	Productivity	Eggs, fry, and 0+	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Continue to promote no-till farming and other seeding techniques that reduce erosion where site conditions are suitable	SWCD, NRCS	Ongoing	High dispersal downstream	Long Term	5-15 years	Moderate to high depending upon the rate of participation by landowners
Restore native upland plant communities	SWCD, USFS, BLM	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term	5-30 years	Moderate to high depending upon how severely impacted the sites are and how successful prescribed treatments are
Upgrade or remove problem forest roads	USFS, ODF	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff. Decommissioning may take many years	5-15 years	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Initiate upland improvement demonstration projects	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed
Manage vegetation, including juniper removal	USFS, BLM, NRCS, SWCDs, Watershed Councils	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Juniper control can be done relatively quickly, other strategies such as control of invasive plants may take more than 20 years	5-30 years	Moderate
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	SWCD, VSFS, ODA, CTWSRO, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of Agricultural Water Quality Management Plans	0-20 years, depending upon treatments applied	Moderate, dependent upon voluntary landowner participation

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS, Farm Service Agency	CRP	Lower and Middle Rock, Thirtymile, Grass Valley, Pinehollow, Ferry, and Butte crs	No	Program needs expansion, effective where applied.
SWCDs	Juniper control	Butte, Service, Bridge crs	Uncertain	More effective if expanded.
ODFW	Green Forage		Uncertain	Very small program, could be expanded.
USFS, BLM	Individual Forest or Area Management Plans, PACFISH	Bridge, Cottonwood, Lower John Day, Butte, Hay, Rock/Mountain, Upper Rock, and Kahler crs	Yes, but dependent on consistent implementation	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005).
ODA	Agricultural Water Quality Management Program	Population-wide		See State of Oregon programmatic review -- Appendix F.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Pine Cr	Yes, where implemented	More acreage needs to be treated.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Programs initiated by the NRCS, SWCDs and ODFW are relatively small, with the CRP program the largest and best funded. CRP has been in existence for 20 years and has been one of the better farm subsidy programs for watershed restoration. The CRP program has focused on the Lower John Day River (primarily below Thirtymile Cr) where dry land grain crops are grown and where significant acres of highly erodible soil exist. Juniper control programs have focused on areas where extensive juniper encroachment has occurred. Juniper control can be completed using several different methods, including controlled burns, cutting with chainsaws, or by removing with bulldozers or trackhoes. Although controlled burns are probably the most effective at controlling the spread of juniper, they are the most difficult to implement because of the threat of the fire getting out of control and costs. Another drawback to controlled burns is that livestock grazing should be excluded from burned areas for at least two growing seasons after the burn to ensure full recovery of desirable perennial grasses. There are opportunities to expand the juniper control program but the lack of a pasture to put livestock into for two years after burning has limited its acceptance. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize FS restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. The ODFW Green Forage program provides a wildlife seed mixture of native grasses and desirable forage to landowners who have recently completed juniper clearing projects, logging projects or other ground disturbing activities. The primary purposes are to provide additional forage for deer and elk and to reduce deer and elk damage complaints; however it also has benefits to watershed health by providing grasses that provide perennial ground cover. The limitations to all the programs are funding and, to a lesser extent, acceptance by landowners.				

9.3.6 Habitat Strategies and Actions for North Fork John Day River Steelhead Population

Primary limiting factors: Degraded channel structure and complexity (habitat quantity, diversity and channel stability), altered sediment routing, water temperature, altered hydrology, degraded floodplain function and connectivity.

Primary threats: riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, irrigation withdrawals, mining, and dredging.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition or conservation easements	Tributaries of the North Fork John Day River within the NF John Day Wilderness (1); North Fork John Day River, from Big Cr upstream to headwaters (1); Granite Cr (2); South Fork Desolation Cr (1); upper Clear Cr (1); upper Hidaway Cr. (2)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing	Many threats including livestock overgrazing of riparian area, mining, channelization, stream bank armoring, agricultural practices (fertilizers, herbicides, sediments, changes in plant communities), water withdrawals, loss of beaver dams	Abundance, productivity	All	Protection of high quality habitats is the most cost effective way of ensuring high quality habitat. It is much less expensive over the long term to protect high quality habitat than it is to degrade the habitat and then try to restore it. Land acquisitions, easements, and cooperative agreements facilitate protection.
Adopt and manage Cooperative Agreements	Cottonwood (1); Deer (1), and Rudio crs (2); North Fork John Day River, below Wall Cr (2)	Same as above	Same as above	Abundance, productivity	All	
Special management designations in forest and BLM plans	Recently acquired BLM parcels on the North Fork John Day River, between Monument and Camas Cr (1); areas identified in existing Forest Plans (2)	Same as above	Livestock overgrazing of some riparian areas, changes in plant communities	Abundance, productivity	All	
Designate additional wilderness and wild and scenic status	Those areas identified in the Umatilla National Forest Plan Revision and in the BLM Management Plan currently being developed (2)	Same as above	Livestock overgrazing of riparian area, changes in plant communities	Abundance, productivity	All	
Protect access to key habitats	The lower reaches of Hideaway (1), Cable (1), Desolation (1), Owens (2), Camas (2), Meadowbrook (2), Rudio (2), and Cottonwood (1) crs	Passage barriers, altered hydrology, channel structure		Abundance, productivity, distribution		Current state law requires ODFW to review any new or substantially modified structure with regard to fish passage. Potential still exists for access to be blocked by warm water temperatures and flow alterations. Channel structure may be severely modified by higher than natural flows.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	Population-wide	All	Same as above	Abundance, productivity	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements	CTUIR, TNC, RMEF, John Day Basin Trust, SWCDs	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5-15 years with passive restoration approaches	High, based on previous cooperative agreements
Adopt and manage Cooperative Agreements	ODFW, SWCDs, FSA	Ongoing	Same as above	Agreements are for 10-15 years	Long term	High, although not in perpetuity
Special management designations in forest and BLM plans	USFS, BLM	Ongoing as identified	Same as above	Many complete, potentially subject to change in Forest Plan revisions	Immediate and long term	High, although subject to change from Forest Plan or management plan revision
Designate additional wilderness and wild and scenic status	UDFS, BLM Oregon State Parks	Ongoing as identified	Water quality and flow improvements would have high dispersal downstream, stream corridor and function improvements confined to the specific site	Unknown	5-15 years	Unknown, subject to availability of areas that meet criteria
Protect access to key habitats	SWCDs, Watershed Councils, BLM, USFS	Ongoing	Immediate area only	Long term	5-15 years	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	NRCS, SWCDs, USFS, ODFW, ODF, DSL, BLM, ODOT, CTWSRO, ODA, FSA, private landowners	Ongoing	Population-wide	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS, BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management Area designations, PACFISH	FS and BLM lands for PACFISH, North Fork Wilderness, North Fork Wild and Scenic Corridor	Yes, PACFISH standards are good, but implementation is inconsistent between forests. See discussion below.	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW	Cooperative Agreements	Privately owned lands, Camas, Cottonwood/Fox, Granite creeks	No	The agreements are for only 10-15 years and need to be for longer timeframes.
FSA	CREP	Privately owned lands, primarily on Cottonwood/Fox Creek	No	The agreements are for only 10-15 years and need to be for longer timeframes.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
NGOs	Lease or purchase of lands	Cottonwood Creek conservation easement	Yes	Important to secure critical habitat and/or water rights.
ODA	Agricultural Water Quality Management Program	Private lands throughout the North Fork watershed		See State of Oregon programmatic review -- Appendix F.
CTUIR	Watershed Restoration	Camas and Desolation creeks	Uncertain	Needs expansion.
ODF	Oregon Forest Practices Act	Private and state owned lands		See State of Oregon programmatic review -- Appendix F.
Local Government	City and County Planning and Zoning	Private lands	Uncertain	Needs expansion.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The North Fork John Day River from Camas Cr (RM 57) to the headwaters (RM 112) is designated as a Federal Wild and Scenic River. The North Fork John Day from near Monument (RM 20) to the North Fork wilderness boundary (RM 76.5) is designated a State Wild and Scenic River. A wild and scenic designation requires development to be consistent with protecting the ORVs for which the river was designated, requires review of any activity that may affect ORVs within the ¼ mile river corridor, and protects the free flowing condition of the river. Designation as W&S essentially precludes construction of any major dam. A Management Plan was adopted by BLM and Oregon State Parks Department in 2001 for the designated rivers segments. Implementation of all the actions identified in the plan will likely take many years, however grazing management plans for most of the allotments within corridor are complete. All BLM allotments have grazing plans, except recently acquired lands. Wilderness areas within the boundaries of the North Fork population include the North Fork John Day Wilderness (85,000 acres). The primary rationale for designating the North Fork Wilderness was for protection of anadromous fish habitat. Adding additional wilderness areas and wild and scenic river segments would require designation by Congress. Implementation of PACFISH standards and guides for Forest and BLM programs, including grazing management, has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management programs remains challenging in a few locations. Cooperative and conservation agreements on private land are tools for protecting high quality habitats. ODFW has used cooperative agreements over the last 21 years to protect riparian corridors that have been fenced to exclude livestock grazing. Unfortunately those agreements are for only 15 years and there have not been funds or personnel needed to extend them for longer time periods. In the North Fork subbasin, a perpetual conservation agreement to prevent subdividing a 10,000 acre parcel is in place on Gilmore and Straight crs and includes approximately 3.3 miles of steelhead spawning and rearing habitat. See discussion for Strategy 1, Lower Mainstem John Day River population.				

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Remove or minimize use of push up dams	Cottonwood Cr/Fox drainage (1)	Impaired fish passage	Push up dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Push up dams are common in the Cottonwood Cr drainage. Passage problems at culverts are widespread throughout all subbasins. Annual maintenance and construction of push up dams contributes to onsite and downstream channel stability, loss of pools and other structure, and increased sediment loads.
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	For irrigation related passage issues: Cottonwood Cr/Fox drainage (1) For culverts: SF Trail, Meadowbrook (1), Upper Granite (2) crs	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Push up irrigation dams, concrete diversions, in-channel stock ponds, and road culverts are located throughout the entire subbasin.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Construct ladders over existing permanent concrete or earth fill dams, or remove the barrier	None currently identified	Impaired fish passage	Dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	A comprehensive barrier assessment has not been completed for all private lands, so there may be a few barriers that are not currently identified
Provide screening at 100% of irrigation diversions	Cottonwood/Fox Cr (1).	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry, juveniles, and smolts	All unknown existing screens meet criteria

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove or minimize use of push up dams	SWCD	Ongoing	Provide access to upstream habitat	Ongoing, but all push up dams not expected to be corrected for at least 15 years. A comprehensive barrier assessment has not bee completed.	Immediate	High, if comply with fish passage design criteria
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	USFS, watershed councils, SWCDs, ODOT	Ongoing	Access to upstream habitat	Ongoing, replacing all culverts blocking fish passage expected to take 50 years (see Appendix G)	Immediate	High, if comply with fish passage design criteria
Construct ladders over existing permanent concrete or earth fill dams	ODFW, SWCDs	Ongoing	Provide access to upstream habitat	Ongoing, providing passage at all diversion and pond barriers will take many years. A comprehensive barrier assessment has not bee completed.	Immediate	High if comply with fish passage design criteria
Provide screening at 100% of irrigation diversions	ODFW, SWCDs	Ongoing	At point of diversion	Approximately 3 diversions need to be screened	Immediate	High if comply with fish screening design criteria

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Soil and Water Conservation Districts	Irrigation dam improvements, culvert replacement or retrofits	Unscreened or poorly screened diversions throughout populations	Likely	The Grant Soil and Water District is constrained by the construction window of opportunity. Other counties could expand the program but are constrained by funding and personnel. See State of Oregon programmatic review – Appendix F.
ODFW	Fish Passage/Screening	Unscreened or poorly screened diversions throughout populations	No	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding. Rate of implementation needs accelerated.
USFS	Culvert replacement	Federally owned lands, Meadowbrook Creek	Uncertain	Based on total number of identified problem culverts on federal lands, will take about 50 years at current rate to complete culvert replacements. See comments below in Gaps section.
Watershed Councils	Road Crossing Passage improvements, passage improvements	Privately owned lands, primarily in North Fork John Day and tributaries below and including Wall Creek	No	Rate of implementation slow, technology sufficient to deal with threats.
ODOT	Culvert replacement or retrofit	State and Federal highway systems	Uncertain	See State of Oregon programmatic review – Appendix F.
BOR	John Day Basin Program	Privately owned lands as identified by SWCDs and Watershed Councils	Yes	Program rate sufficient.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.				
CTWSRO, CTUIR	John Day Basin Program	Privately owned lands, primarily in Camas, Desolation, and lower NF tributaries	No	The tribes contract with Soil and Water Districts to assist with consultation, permits, and monitoring; additional efforts needed to address problems in a timely manner.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Most of the mainstem passage problems have been addressed, but there are many tributaries where adult passage is blocked and more areas where juvenile passage problems occur. Irrigation dams, stock ponds, and road culverts are the primary causes of passage issues. Soil and Water Districts are correcting passage at irrigation diversions and improperly installed culverts, but are constrained by funding and by personnel needed for construction oversight. Watershed councils and ODOT, who are the principal entities working on culverts are constrained primarily by funding. An inventory of road crossings on federal lands indicates juvenile passage problems are pervasive, particularly on National Forests, with approximately 200 culverts not meeting passage criteria in this population. The BLM has no adult barriers at culverts. Monitoring is needed to determine if upstream passage for juveniles is an issue. The US Forest Service and BLM are constrained primarily by funding and the personnel needed for NEPA analysis. At the current rate of culvert replacements, it will take over 50 years to correct all passage problems on National Forests. Another constraint is that existing state laws do not require passage improvements at existing barriers unless there is a major change in the structure, such as reconstruction or significant modifications, so landowner cooperation is critical for improving passage throughout the subbasin.

The Malheur, Wallowa Whitman, Umatilla and Ochoco National Forests have culvert inventories for their lands. The Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005), provides guidance that will help prioritize culvert replacements for this population. ODFW has an inventory of culverts on state and county-owned roads. Appendix G presents an inventory of culverts with known passage problems on state, county, and USFS owned roads. The inventory shows there are three culverts on state owned roads and one culvert on county owned roads that do not meet fish passage criteria within the North Fork population boundary. There has not been an inventory of road culverts on private lands.

US Bureau of Reclamation, as required in the Columbia River Biological Opinion, is required to identify and assist with passage improvement design and flow restoration.

See discussion for ODFW Fish Passage and Screening program in Strategy 2, Lower Mainstem John Day River population.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Camas Cr, from Wilkins Cr to Cable Cr (2), Owens Cr (1), Clear Cr below Ruby Cr (2), Beaver Cr below Olive Cr (1), Bull Run Cr (1), Crane Cr above Forest Rd 73 (2), lower Boulder Cr (Granite Cr trib) (2), Cottonwood Cr below EF Cottonwood (1)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily fry and 0+	
Reconnect side channels and off-channel habitats to stream channels and reconnect surface flow/restore fish passage in tributaries.	Camas Cr from Wilkins Cr to Cable Cr (2), Owens Cr (1), Clear Cr below Ruby Cr (1), Beaver Cr below Olive Cr (2), Bull Run Cr (1), Crane Cr above Forest Rd 73 (2), lower Boulder Cr (Granite Cr trib) (2), Cottonwood Cr below EF Cottonwood (1)	Degraded floodplain, altered hydrology	Removal of side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity, spatial structure	Primarily fry and 0+	There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows.
Restore wet meadows	Cottonwood/Fox, Granite (1), Owens (2), Camas from Wilkins Cr to Cable Cr (2), Upper Wilson Cr (1)	Degraded floodplain, altered hydrology	Removal of wetlands	Abundance, productivity	Primarily fry and 0+	
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	Camas Cr from Wilkins Cr to Cable Cr (1), Owens Cr (1), Clear Cr below Ruby Cr (2), Rudio (1), Wall (1), Wilson (2), Beaver Cr below Olive Cr (2), Bull Run Cr (2), Boulder Cr (2), Crane Cr above Forest Rd 73 (2), lower Boulder Cr (Granite Cr trib) (2), Cottonwood (1), Fox Cr (1)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity, spatial structure	Primarily fry and 0+	

Strategy 3. Maintain and restore floodplain connectivity and function.						
Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Reconnect floodplain to channel	ODFW, watershed council, SWCD, USFS, BLM	Ongoing	For the treated stream reach	Short term, once identified	Physical response will be immediate; biological response up to 5-10 years	High
Reconnect side channels and off-channel habitats to stream channels	ODFW, watershed council, SWCD, USFS, BLM, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, because of widespread need	5-15 years, depending upon frequency and duration of channel altering flows	Moderate, depending upon how extensive project is and frequency/duration of channel altering flows
Restore wet meadows	TNC, USFS, CTWSRO	Ongoing and planned	Benefits of improved channel morphology localized, improved water table and resulting increased streamflow and lower water temperatures have high dispersal downstream	Intermediate	5-15 years	Moderate
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	ODFW, CTWSRO, USFS, BLM	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, due to acceptance by landowners and widespread need	Within 15 years once the beavers are well established	Moderate-high, dependent upon acceptance by landowners

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	**Program Name**	**Geographic Locations**	**Sufficient* (yes, likely, uncertain, no)**	**Sufficiency Rationale**
ODFW	BPA Habitat Program	Cottonwood/Fox Creek, other privately owned lands when specifically identified	No	If specific needs cannot be addressed by passive restoration techniques then active measures taken. Program has limited resources.
USFS, BLM	Stream enhancement program	Granite Creek, NF John Day between Big and Desolation creeks for USFS and blocks of BLM on NF and tributaries between Camas Creek and Monument, but only when specifically identified that passive restoration is not working	Yes in some areas, no in others due to limited funding	The USFS/BLM preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	Private lands between Camas Creek and Kimberly	Uncertain	Dependent on future funding.
Soil and Water Conservation Districts	Watershed restoration	Private lands between Camas Creek and Kimberly		See State of Oregon programmatic review – Appendix F.
Nature Conservancy and other NGOs	Restoration projects	None currently identified, but may be opportunities in the future	Yes	Sufficiency yes when opportunities arise.
CTUIR	Watershed restoration	Camas Creek, Desolation Creek, and other privately owned lands	Uncertain	Program could be expanded.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategic Actions and Impacts on Limiting Factors, Threats, and Population

Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Camas Cr, from Wilkins Cr to Cable Cr (1), Owens Cr (2), Clear Cr below Ruby Cr (1), Beaver Cr below Olive Cr (1), Bull Run Cr (1), Crane Cr above Forest Rd 73 (2), lower Boulder Cr (Granite Cr trib) (2), Cottonwood Cr below EF Cottonwood (1).	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature, flows	Stream channelization, bank armoring, large wood removal, beaver removal, removal of riparian vegetation, livestock overgrazing in riparian areas	Abundance, productivity	Primarily fry and 0+	Passive restoration techniques, such as riparian fencing, are the preferred method for improving channel structure and stability. More active restoration techniques may be appropriate in these reaches.
Place stable wood and other large organic debris in streambeds and in floodplains	Camas Cr (2), Owens Cr (2), Clear Cr (1) below Ruby Cr, Beaver Cr (1) below Olive Cr, Bull Run Cr (1), Crane Cr (2) above Forest Rd 73, lower Boulder Cr (1) (Granite Cr trib), Cottonwood/Fox Cr (1), Desolation Cr (2), Rudio (2)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal, channelization	Abundance, productivity	Primarily fry and 0+	More active restoration techniques, such as rootwad placement or channel reconfiguration, may be appropriate in these reaches when passive restoration techniques have not been successful
Stabilize streambanks	Camas Cr (1) from Wilkins Cr to Cable Cr, Owens Cr (2), Cottonwood Cr below EF Cottonwood (1).	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily eggs, fry and 0+	Some bank erosion is inevitable and beneficial. However, where erosion is actively taking place due to unnatural processes, stabilization may be needed to reduce fine sediments

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, USFS, BLM, watershed councils	Ongoing and planned	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Place stable wood and other large organic debris in streambeds and in floodplains	ODFW, USFS, watershed councils, BLM, SWCDs	As needed	For the immediate stream reach	Short term, once identified	Immediate	High
Stabilize streambanks	ODFW, USFS, watershed councils, BLM, SWCDs	Ongoing	For the treated stream reach, physical benefits dispersed downstream	Passive stabilization techniques are preferred and take longer to implement	With passive restoration the response may take 15 years	Medium to high, depending upon the extent of the treatments

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Cottonwood/Fox, Granite, Rudio, and Deer creeks, NF below Monument, but only when specifically identified that passive restoration is not working	No	Program has limited resources.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.				
USFS, BLM	Stream enhancement program	NF between Camas and Big Creek for USFS and BLM blocks between Kimberly and Camas Creek, but only when specifically identified that passive restoration is not working	Yes in some areas, no in others due to limited funding.	The USFS/BLM preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	NF between Wall Creek and Kimberly, Rudio, Cottonwood/Fox, and Deer creeks. Only when specifically identified that passive restoration is not working	Uncertain	Depends on availability of funds.
Soil and Water Conservation Districts	Watershed restoration	Granite Creek, NF John Day between Wall Creek and Kimberly. Only when specifically identified that passive restoration is not working		See State of Oregon programmatic review – Appendix F.
CTWSRO, CTUIR	Watershed restoration	Granite, Camas, and Desolation, Creeks. Only when specifically identified that passive restoration is not working	Uncertain	Funding future uncertain.
NGOs	Watershed restoration	None currently identified. Only when specifically identified that passive restoration is not working	Uncertain	No current activities.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Instream activities have not been identified as a high priority by the recovery planning team or the subbasin plan team except when identified as a need for specific sites. The planning team prefers that more passive approaches, such as riparian and upland improvements be emphasized. Typically, instream activities that would improve floodplain function and channel migration processes would include placement of rootwads, whole trees, or boulder clusters to improved habitat complexity and habitat diversity where those parameters are deficient and not expected to improve with passive restoration. Another structural activity would be to construct boulder or log weirs to raise the water table, but only where a passive approach has not worked. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	Rudio (2), Cottonwood below Fox Cr (1), Deerhorn (2), Jericho (2), Camas above Wilkins Cr (1), and Desolation from the mouth to Park Cr (2)	Degraded riparian area, channel structure and complexity, floodplain degradation, altered hydrology, sediment, water quality	Overgrazing of riparian area, channelization, stream bank armoring, tree harvest in riparian areas, changes in plant communities (including invasive plants), loss of beaver dams	Abundance, productivity	Primarily fry and 0+	Primary methods of riparian enhancement include riparian corridor fences to exclude livestock, changes in grazing management that promote riparian recovery, and planting of native shrubs.
Develop grazing strategies that promote riparian recovery	Rudio (2), Cottonwood below Fox Cr (1), Deerhorn (2), Jericho (2), Camas above Wilkins Cr (1), and Desolation from the mouth to Park Cr. (2), recently acquired BLM parcels on the North Fork John Day River, between Monument and Camas Cr (1)	Same as above	Livestock overgrazing of riparian area	Abundance, productivity	Primarily fry and 0+	

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities including vegetative planting	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years (see above)	High, based upon experience with existing grazing management and riparian recovery projects
Develop grazing strategies that promote riparian recovery	NRCS, AFS, USFS, BLM, SWCDs, ODFW, Watershed Councils, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, depending upon grazing plan adopted. Riparian corridor fencing and removal of riparian grazing has the fastest recovery rate.	High, based upon experience with existing grazing management and riparian recovery projects

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Cottonwood/Fox, Camas, and Granite creeks	No	Insufficient resources.
SWCDs	Upland improvements, riparian improvements	Private lands on Rudio, and Cottonwood creeks, NF John Day between Monument and Kimberly		May need additional resources. See State of Oregon programmatic review – Appendix F.
Watershed Councils	Upland improvements, riparian improvements	Private lands on Rudio, and Cottonwood creeks, NF John Day between Monument and Kimberly	No	Need additional resources.
USFS and BLM	Upland improvements, riparian improvements	NF John Day between Wall and Camas Creek for BLM and NF John Day and tributaries above and including Camas Creek for USFS	Uncertain	See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.
NRCS	Upland improvements, riparian improvements	Private lands on NF John Day below Wall Creek	Yes	Deemed sufficient.
ODA	Agricultural Water Quality Management Program	Private lands within the NF watershed		See State of Oregon programmatic review -- Appendix F.
CTUIR	Watershed restoration	Camas, Desolation, and Deer creeks on private land.	Uncertain	Limited by resources.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

See discussion for Strategy 5, Lower Mainstem John Day River population. Implementation of PACFISH standards and guides has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management programs remains challenging in a few locations. Forest Services's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	Cottonwood/Fox (1), lower Rudio Cr (1), Mainstem North Fork below Wall Cr (2)	Altered hydrology, low flows, high temperatures	Water withdrawals, land conversion on uplands, road network	Abundance, productivity	Fry and 0+	Cottonwood/Fox and lower Rudio Crs are the tributaries most affected by irrigation withdrawals. The mainstem North Fork below Wall Cr has numerous irrigation withdrawals, but warm water temperatures preclude steelhead from using for year long rearing.
Improve irrigation conveyance and efficiency	Cottonwood/Fox (1), lower Rudio Cr (1), Mainstem North Fork below Wall Cr (2)	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Fry and 0+	
Increase pool habitat (beaver ponds)	Cottonwood/Fox (1), Rudio (1), Granite (2), Olive (2), Clear (2), Owens (1), Desolation (2), Wilson (1), and Wall(1) crs, Camas Cr above Wilkins Cr (1)	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Fry and 0+	
Floodplain aquifer recharge	Camas Cr above Wilkins Cr (1)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	
Lease or acquire water rights and convert to instream	Cottonwood/Fox (1), lower Rudio Cr (2), Mainstem North Fork below Wall Cr (2)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	Annual fluctuations in flow levels are intensified by irrigation withdrawals
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Altered hydrology, low flows, high temperatures, impaired natural functions and processes on uplands, floodplains, riparian areas	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Fry and 0+	Changes in the upland plant community due to fire suppression, invasive plants, and conversion of bunch grass prairies to wheat fields have resulted in lower precipitation infiltration rates, which results in higher peak flows and lower low flows. Some tributaries are now dry where they join the John Day River. Removal of large wood and channelizing streams also increases water velocities and reduces the ability of the stream to hold water for gradual release.
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
incentive funding to develop strategies to meet long-term needs						
Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD, watershed councils, NRCS	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights
Improve irrigation conveyance and efficiency	SWCD, OWEB, watershed councils, NRCS, landowners	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights
Increase pool habitat (beaver ponds)	SWCD, ODFW, CTWSRO, USFS	Ongoing	High dispersal downstream	unknown	Immediate increase in instream flow	High
Floodplain aquifer recharge	CTWSRO, SWCDs	Planned, some ongoing	Potentially high dispersal from recharge project site downstream for many miles	Long term, although opportunities for pilot projects is dependent upon willing landowner	Immediate	High, if the additional water is protected from being appropriated to a downstream user in areas with instream water rights
Lease or acquire water rights and convert to instream	OWRD, FSA, OWEB, Oregon Water Trust, others	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and highly dependent upon landowner willingness to lease.	Immediate	High, if the leased water is protected from being appropriated to a downstream user in areas with instream water rights. FSA pays higher rates for CREP enrollment when water rights are leased for instream use.
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion downstream to mouth of John Day River	Long term, dependent upon OWRD enforcing the requirement to measure water usage	Immediate	High if water user reporting requirement and installation of measuring devices on diversions is implemented
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD, USFS, BLM, OWRD, OWEB, ODFW, CTWSRO, landowners	Ongoing	MaSAs	Intermediate	Up to 15 years	High
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program, riparian improvements	Private lands on Cottonwood/Fox, Rudio, Camas, and Granite creeks	No	Program has limited resources.
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Cottonwood/Fox, Rudio, NF John Day below Wall Creek and other streams with water withdrawals		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust and BOR	Leasing and Purchase of Water Rights	No existing sites identified	Uncertain	Depends on opportunities and funding.
Soil and Water Conservation Districts	Improve irrigation efficiency, upland improvements, riparian improvements	Cottonwood/Fox, Rudio, Deer and Granite creeks, and NF John Day below Wall Creek		See State of Oregon programmatic review – Appendix F.
Watershed Councils	Upland improvements, riparian improvements	Cottonwood/Fox, Rudio, Deer and Granite creeks, and NF John Day below Wall Creek	No	Program has limited resources and needs expansion.
NRCS	Upland improvements, riparian improvements	Cottonwood/Fox, Rudio, Deer and Granite creeks, and NF John Day below Wall Creek	No	Program needs expansion.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Approximately 170 miles of stream in the North Fork are protected with either existing or pending instream water rights. The instream water rights do not preclude further appropriation of water until flows in the affected reach drop down to the instream water rights as adopted by OWRD. Voluntary efforts restored 1.2 cfs instream in 2006. See discussion for Strategy 6, Lower Mainstem John Day River population.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Increase riparian shading	North Fork John Day River below Camas Cr (2), Camas Cr. (1), Lower Cottonwood Cr. (1), Rudio Cr. (1), Owens Cr. (1), lower reaches of Wall (2), Desolation(2), and Wilson (2) Crks.	High water temperatures	Degraded riparian forests	Abundance, productivity	Eggs, fry, juveniles, adults	Elevated water temperature is a pervasive water quality problem for the North Fork John Day River population, with 39 stream reaches listed as water quality limited. Additional reaches would probably be listed if water temperature data were available. Camas, Owens and Cottonwood crs and lower reaches of Wall, Desolation, and Wilson crs are relatively good producers of steelhead that are listed as water quality limited due to elevated water temperatures.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Manage return flow to reduce extreme stream temperatures	lower North Fork John Day River (2) Camas Cr. (1), Cottonwood Cr. (1), Rudio Cr. (1), Owens Cr. (2)	High water temperatures	Water withdrawals	Abundance, productivity	Eggs, fry, juveniles, adults	
Address contamination from mine related discharge	Granite Cr and tributaries (1)	Chemical contaminants	Heavy metal and mine waste pollution	Abundance, productivity	Eggs, fry, juveniles, adults	
Reduce chemical pollution inputs	None currently identified	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity	Eggs, fry, juveniles, adults	
Apply BMPs to animal feeding operations	None currently identified	Degraded water quality	Animal feed operations	Abundance, productivity	Eggs, fry, juveniles, adults	
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	Population-wide	Degraded upland processes, floodplains, riparian areas, altered hydrology, altered sediment routing	Degradation and conversion of uplands, floodplains, riparian areas	Abundance, productivity	Eggs, fry, juveniles, adults	While irrigation is not common in the North Fork, there are some opportunities to use more efficient irrigation methods, which reduces the amount of surface water returning to the stream, and result in fewer nutrients from pastures reaching the North Fork John Day River and its tributaries. Reducing nutrient loads will contribute to increased water quality by reducing biological oxygen demand and algae blooms.
Continue TMDL monitoring	Population-wide	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	Eggs, fry, juveniles, adults	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Increase riparian shading	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years	High
Manage return flow to reduce extreme stream temperatures	SWCDs, watershed councils	Ongoing	Water quality improvement would have high dispersal downstream	Less than 5 years, once the project has been identified	Immediate	High, reduced temperatures has been well documented
Address contamination from mine related discharge	ODEQ, USFS	Ongoing	Primarily in contaminated reaches, with intermediate dispersal downstream	Long term, although actual treatment may take only a matter of days.	Immediate in the specific stream reach.	High, although contingent upon adequate maintenance
Reduce chemical pollution inputs	ODEQ, others	Ongoing		Ongoing	Reduce chemical pollution immediately	High
Apply BMPs to animal feeding operations	ODA	Ongoing	Water quality improvement would have high dispersal downstream	Some treatments could be done immediately. There are few animal feeding operations within the subbasin, only one of which has been identified as a problem	5-15 years	High, once a treatment has been agreed upon

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Restore natural functions and processes through actions identified in strategies 1,3,4,5,8	SWCD, USFS, BLM	Ongoing	Subbasin-wide, high dispersal downstream	Intermediate	Up to 15 years	High
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA	CREP, CRP	Cottonwood/Fox, Rudio, and Camas creeks, NF John Day below Wall Creek	No	Program needs expanded.
ODFW	Riparian Enhancement Program	Cottonwood/Fox, Rudio, and Camas creeks.	No	Constrained by funding and personnel.
ODEQ	Mine Waste Program	Granite Creek		See State of Oregon programmatic review -- Appendix F.
ODA	Confined animal feeding operations (CAFO), AgWQM	None currently identified	Likely	See State of Oregon programmatic review -- Appendix F.
ODEQ, ODA, SWCD, USFS	Sedimentation Monitoring (TMDL Development and Implementation)	Watershed-wide		See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Heavy metal and other contaminants coming from historical and ongoing mining activity in the Granite Cr drainage has resulted in elevated levels of these contaminants found in sediments. ODFW biologists have observed dead fish and adult fish with gill lesions in the streams of this watershed. Although the cause of this mortality is not certain, elevated iron and heavy metal concentrations may be a contributing factor. Although recent surveys conducted by the UNF and U.S. Environmental Protection Agency (EPA) indicated that mercury was not present in high enough concentrations known to cause these types of effects, conditions at abandoned mine sites and abatement ponds may change yearly, increasing the amount of heavy metals released (NMFS 2004/0008). Low stream flows during the hottest part of the year exacerbate the already warm water temperatures. Opportunities for increasing streamflow through leasing of water rights, which often results in cooler water over a longer stream reach, are being pursued by Oregon Water Trust and US Bureau of Reclamation. Constraints for future projects include acceptance by landowners and a secure, long term funding source. Forest Services's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize stream enhancement actions for this population, and helps deploy limited active restoration funding for riparian planting where it is most needed.

Reducing water temperatures through the use of improved riparian vegetation and more efficient methods of irrigation may take several years to provide measurable results. Many projects that improve water quality by reducing irrigation return water have been completed.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore native upland plant communities	Cottonwood/Fox Cr (1), upper Rudio Cr (1), Deer Cr (1), Wilson Cr (2), Wall Cr (2).	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices, loss of water storage capacity	Abundance, productivity	Eggs, fry, and 0+	Upland improvements such as restoring native plant communities and controlling invasive weed species will improve precipitation infiltration rates and ultimately improve watershed health, including the hydrograph.
Upgrade or remove problem forest roads	Upper North Fork John Day River and tributaries above and including Trail Cr (1), Wilson Cr (2),	Same as above	Road network	Abundance, productivity	Eggs, fry, and 0+	

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
	Upper Camas Cr tributaries (2), Clear Cr and tributaries (1), Granite Cr (2)					
Initiate upland improvement demonstration projects	Population-wide	Same as above	Upland land use practices	Abundance, productivity	Eggs, fry, and 0+	
Manage vegetation, including juniper removal	Cottonwood/Fox Cr (1), upper Rudio Cr (2), Deer Cr (2), Wall Cr (1), Wilson Cr (2)	Altered hydrology, sediment routing	Invasive plants	Abundance, productivity	Eggs, fry, and 0+	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Population-wide	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	Eggs, fry, and 0+	Suppression of fires over the last 80 years has contributed to higher than normal tree densities and increased threat of high intensity fires. High intensity fires have greater potential for damaging watershed function than lower intensity fires. There are areas on National Forest lands that have degraded conditions due to fire suppression, but they are difficult to quantify.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore native upland plant communities	SWCD, USFS, BLM	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term		
Upgrade or remove problem forest roads	USFS, ODF, ODOT	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff. Decommissioning may take many years	5-15 years	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Initiate upland improvement demonstration projects	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	unknown, depends upon action taken as a result of being more informed
Manage vegetation, including juniper removal	USFS, BLM, NRCS, SWCDs, Watershed Councils	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Juniper control can be done quickly, other strategies such as control of invasive plants may take more than 20 years	5-30 years	Moderate
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road	SWCD, USFS, BLM, ODA, CTWSRO, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of Agricultural Water Quality Management Plans	0-20,years, depending upon treatments applied	Moderate, dependent upon voluntary landowner participation

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
management and agricultural practices						
Status of Existing Programs through which Actions are Implemented						
Agency/Organization	**Program Name**	**Geographic Locations**	**Sufficient* (yes, likely, uncertain, no)**	**Sufficiency Rationale**		
NRCS, Farm Service Agency	CRP	Rudio, Lower Cottonwood, NF John Day below Wall Creek	No	Needs expansion.		
SWCDs	Juniper control	Rudio and Cottonwood creeks	No	Needs expansion.		
ODFW	Green Forage	Rudio and Cottonwood creeks	No	Very small program.		
USFS, BLM	Forest Plan, Resource Management Plan, PACFISH	All FS/BLM lands throughout watershed	Likely	See USFS/BLM Program Sufficiency Assessment -- Appendix E and Regional Aquatic Restoration Strategy. See discussion in Gaps commentary below.		
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.		
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.		
ODA	Agricultural Water Quality Management Program	Private lands throughout the watershed		See State of Oregon programmatic review -- Appendix F.		
CTUIR	Watershed Restoration	Camas and Desolation creeks on private lands	Uncertain	Limited resources.		
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)						
See discussion for Strategy 8, Lower Mainstem John Day River population. Implementation of PACFISH standards and guides (BMPs) to Forest and BLM programs, has been highly successful for passive upland restoration over most of this population's area. Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize active watershed restoration for this population, and helps deploy limited active watershed restoration funding where it is most needed.						

9.3.7 Habitat Strategies and Actions for Middle Fork John Day River Steelhead Population

Primary limiting factors: degraded channel structure and complexity (habitat quantity and diversity), degraded floodplain function and connectivity, altered sediment routing, altered hydrology, and water temperature.

Primary threats: riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, passage barriers, irrigation withdrawals, mining, and dredging.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition or conservation easements	Upper reaches of Big, Big Boulder, and Granite Boulder crs that originate in the Vinegar Hill-Indian Rock Scenic Area (1); Other areas with high potential for protection once they are restored include the Middle Fork mainstem from Ragged Cr to the upper end of Phipps Meadow (2), and streams that drain the north side of Dixie Butte -- Davis (2), Butte (2), Placer Gulch (2), and Greenhorn (2) crs.	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing,	Many threats including livestock overgrazing of riparian area, channelization, stream bank armoring, agricultural practices (fertilizers, herbicides, sediments, changes in plant communities), water withdrawals, loss of beaver dams	Abundance, productivity	All	Protecting base streamflows from further appropriations is a very important function of protecting existing high quality habitats. Protection of high quality habitats is the most cost effective way of ensuring fish have good quality habitat. Land acquisitions, easements, and cooperative agreements may also facilitate the implementation of active restoration projects.
Adopt and manage Cooperative Agreements	Middle Fork between Placer Gulch and Caribou Cr (1); through Phipps Meadow (1), from Ragged to Tincup Cr (1), from Paradise Canyon to below Lick Cr.(2), Granite Cr (2)	Same as above	Same as above	Abundance, productivity	All	
Special management designations in forest and BLM plans	Riparian Habitat Conservation Areas identified in existing Forest Plans	Same as above	Same as above	Abundance, productivity	All	
Designate additional wilderness and wild and scenic status	Public lands identified in the Forest Plan Revision process	Same as above	Same as above	Abundance, productivity	All	
Protect and conserve rare and unique functioning habitats	Phipps Meadow (1)	Same as above	Same as above	Abundance, productivity	All	It is much less expensive over the long term to protect high quality habitat than it is to degrade the habitat and then try to restore it.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Protect access to key habitats	None identified at this time, although ODFW periodically reviews proposals that could block passage into spawning and rearing habitat.	Passage barriers, altered hydrology, channel structure	High water temperatures, low flow, channelization	Abundance, productivity, distribution	All	Thoroughly review projects that may block fish passage. Current ODFW policy is to grant exemptions from fish passage requirements only if mitigation meets or exceeds the loss of habitat. Exemptions must be approved by the Fish and Wildlife Commission.
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	Population-wide	All	Same as in first cell above	Abundance, productivity	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements	CTUIR, TNC, RMEF, John Day Basin Trust, SWCDs	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5-15 years with passive restoration approaches	High, based on previous cooperative agreements
Protect and conserve rare and unique functioning habitats	Land trusts, CTWSRO, ODFW, SWCD, NGOs, USFS	Ongoing	Same as above	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5-15 years with passive restoration approaches	High, based on previous cooperative agreements
Adopt and manage Cooperative Agreements	ODFW, SWCDs, FSA	Ongoing	Same as above	Agreements are for 10 to 15 years	Immediate	High, although not in perpetuity
Special management designations in forest and BLM plans	USFS, BLM	Ongoing as identified	Same as above	Subject to Forest Plan Revision timeframe for designation	Immediate	High, although subject to change from Forest Plan or mgmt plan revision
Designate additional wilderness and wild and scenic status	Public lands identified in the Forest Plan Revision process	Same as above	Same as above	Intermediate, depending on socio-political acceptance	5-15 years	High if designated
Protect access to key habitats	ODFW, USFS, BLM, Watershed Councils, SWCDs	Ongoing	Same as above	Immediate	Immediate	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	NRCS, SWCDs, USFS, ODFW,ODF, DSL, BLM, ODOT, CTWSRO, ODA, FSA, private landowners	Ongoing	Population-wide	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS/ BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management designations, PACFISH	Indian Rock/Vinegar Hill Scenic Area and buffers on FS and BLM lands	Yes, PACFISH standards are good, but implementation is inconsistent between forests. See discussion below.	See USFS/BLM Program Sufficiency Assessment -- Appendix E.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
ODFW	Cooperative Agreements	Middle Fork private lands with cooperative agreements, Camp Creek and Phipps Meadows	No	The agreements are for only 10-15 years and need to be longer.
FSA	CREP	Middle Fork on Oxbow and Forrest Ranch properties owned by CTWRSO	No	The agreements are for only 10 or 15 years and need to be longer.
NGOs	Lease or purchase of lands or instream water rights	Conservation easement on Middle Fork John Day RPB property and The Nature Conservancy Middle Fork Preserve	Yes	Important to secure critical habitat and/or water rights as additional opportunities arise.
ODA	Agricultural Water Quality Management Program	Private lands		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Oxbow and Forrest Ranch properties and other private lands	Likely	Could be expanded to include other areas.
ODF	Oregon Forest Practices Act	Private and state owned timber lands		See State of Oregon programmatic review -- Appendix F.
Local Government	City and County Planning and Zoning	Private lands	Uncertain	

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The John Day River has 317 miles designated as State Wild and Scenic. State designated reaches include the Middle Fork John Day River from its mouth to Crawford Cr Bridge (RM 71). The Indian Rock Vinegar Hill Scenic Area in the Malheur and Umatilla National Forests is managed primarily for its scenic value, which offers good protection for watershed and fish habitat parameters. Adding addit ional wilderness areas and wild and scenic river segments would require designation by Congress.

Cooperative and conservation agreements on private land are tools for protecting high quality habitats. ODFW has used cooperative agreements over the last 21 years to protect riparian corridors that have been fenced to exclude livestock grazing. Unfortunately those agreements are for only 15 years and there have not been funds or personnel needed to extend them for longer time periods. Over 120 miles of stream throughout the subbasin have been protected under this program. Additional opportunities will be limited by availability of funds and by willingness of landowners to sign conservation easements and/or agreements.

Conservation agreements and acquisitions by conservation organizations are another recently used tool that can protect high quality habitat. The Middle Fork John Day River has five parcels with conservation easements or conservation organizations as the owners. A perpetual riparian conservation agreement restricting development and grazing is currently in place on a 310 acre private parcel in the Middle Fork near river mile 40. Another conservation property is the Nature Conservancy Dunstan Preserve (approx. 1,200 acres) near RM 50. It is managed primarily for fish benefits. The Oxbow Conservation Area (1,022 acres) and the Forrest Conservation Area (approx 867 acres) both owned by the Confederated Tribes of the Warm Springs Reservation of Oregon are managed as mitigation for the loss of fish and wildlife habitat associated with hydroelectric development on the Columbia River. Another privately owned parcel has a perpetual water lease agreement to prevent water withdrawals after July 20, which will result in approximately 10 cfs being left in the stream, primarily for the benefit of salmon and steelhead.

Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management programs remains challenging in some locations.

See discussion for Strategy 1, Lower Mainstem John Day River population.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	**Geographic Locations (1-first priority, 2-second priority)**	**Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Remove or minimize use of push up dams	Long Cr and tributaries (1)	Impaired fish passage	Push up dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Annual maintenance and construction of push up dams contributes to onsite and downstream channel stability, loss of pools and other structure, and increased sediment loads.
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	Irrigation or water storage related issues: Long Cr and tributaries (1) Culverts: Camp (2), Long (1), Vinegar (2), Butte (1), Crawford (2), Granite Boulder (1), and Little Boulder (1) crs	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Push up irrigation dams, concrete diversions, in-channel stock ponds, and road culverts are located throughout the entire subbasin. Passage problems at culverts are widespread throughout all subbasins.
Construct ladders over existing permanent concrete or earth fill dams (complete barrier inventory)	None identified	Impaired fish passage	Dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	A comprehensive survey of all barriers has not been completed, BOR has completed an aerial survey, but has not field verified the potential barriers identified in the aerial survey.
Replace screens that do not meet criteria	Beaver (2), Big, Butte (2), Granite Boulder (2), Long (1), MF John Day (1)	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry	All known diversions in the Middle Fork are currently screened. Most screens within the Middle Fork population boundaries have been replaced to address new criteria to reduce entrainment of emergent fry and bull trout. Priority areas identified where additional upgrades needed.

Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Remove or minimize use of push up dams (complete comprehensive survey)	SWCD	Ongoing	Provide access to upstream habitat	Ongoing, but all push up dams not expected to be corrected for at least 15 years. A comprehensive survey has not been completed.	Immediate	High, if comply with fish passage design criteria
Remove or replace barriers blocking passage -- dams, road culverts and irrigation structures	USFS, BLM, watershed councils, SWCDs, ODOT	Ongoing	Access to upstream habitat	Ongoing, replacing all culverts blocking fish passage expected to take 50 years. See Appendix G.	Immediate	High, if comply with fish passage design criteria
Construct ladders over existing permanent concrete or earth fill dams	ODFW, SWCDs	Ongoing	Provide access to upstream habitat	Ongoing, providing passage at all diversion and pond barriers will take many years.	Immediate	High if comply with fish passage design criteria
Replace screens that do not meet criteria	ODFW	Ongoing	At point of diversion	Approximately 14 diversions need to be replaced, should take - years	Immediate	High if comply with fish passage design criteria

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Soil and Water Conservation Districts	Irrigation dam improvements, culvert replacement or retrofits	Middle Fork John Day, Big Boulder Creek, and other private lands		The Grant Soil and Water District is constrained by the construction window of opportunity. Other counties could expand the program but are constrained by funding and personnel. See State of Oregon programmatic review -- Appendix F.
ODFW	Fish Passage/Screening	Private lands throughout the MF watershed, Bridge Creek	No	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding.
USFS	Culvert replacement	Federal lands, and specifically Granite Boulder and Beaver creeks. See Appendix G for list of the 223 culverts needing replacement.	No	Limited resources result in slow progress and long timeline for completion.
Watershed Councils	Road Crossing Passage improvements, passage improvements	Butte and Bridge creeks, others as identified in Appendix G.	No	Needs additional resources.
ODOT	Culvert replacement or retrofit	Bridge Creek, Summit Creek, Clear Creek		See State of Oregon programmatic review -- Appendix F.
BOR	John Day Basin Program	Private lands throughout the MF watershed as identified by SWCD or Watershed Council.	Yes	Program sufficient.
CTWSRO	John Day Basin Program	Oxbow and Forrest Ranch properties and other private lands as later identified.	No	The tribe contracts with Soil and Water Districts to assist with consultation, permits, and monitoring. Additional resources needed.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Most of the mainstem passage problems have been addressed, but there are many tributaries where adult passage is blocked and more areas where juvenile passage problems occur. Irrigation dams, stock ponds, and road culverts are the primary causes of passage issues. Soil and Water Districts are correcting passage at irrigation diversions and improperly installed culverts, but are constrained by funding and by personnel needed for construction oversight. An inventory of road crossings on state and county roads in 1999 indicated 14 culverts on state owned roads and 4 culverts on county owned roads did not meet fish passage criteria within the Middle Fork population boundary. Appendix G presents an inventory of culverts with known passage problems on state, county, and USFS owned roads. Some culverts have been replaced with structures that do meet the fish passage criteria, but much work remains. Watershed councils and ODOT, who are the principal entities working on culverts are constrained primarily by funding. An inventory of road crossings on federal lands indicates juvenile passage problems are pervasive, particularly on National Forests, with approximately 223 culverts not meeting passage criteria in this population. The US Forest Service and BLM are constrained primarily by funding and the personnel needed for NEPA analysis. At the current rate of culvert replacements, it will take over 50 years to correct all passage problems on National Forests, however, the Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005), provides guidance that will help prioritize culvert replacements for this population. The BLM has no adult barriers at culverts. Monitoring is needed to determine if upstream passage for juveniles is an issue. Another constraint is that existing state laws do not require passage improvements at existing barriers unless there is a major change in the structure, such as reconstruction or significant modifications, so landowner cooperation is critical for improving passage throughout the subbasin. See discussion for Strategy 2, Lower Mainstem John Day River population.				

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Upper mainstem Middle Fork from Big Cr upstream to Idaho Cr (1), Lower Vinegar (2), Vincent (2), and	Degraded floodplain, altered hydrology,	Removal of wetlands, side channels, off-stream	Abundance, productivity	Primarily, fry and 0+	

Strategy 3. Maintain and restore floodplain connectivity and function.						
	Long (1) crs	altered sediment routing, degraded water quality	habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams			
Reconnect side channels and off-channel habitats to stream channels	Upper mainstem Middle Fork from Big Cr upstream to Idaho Cr (1), Lower Vinegar (2), Vincent (2), and Long (1) crs	Degraded floodplain, altered hydrology	Removal of side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity, spatial structure	Primarily, fry and 0+	There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows.
Restore wet meadows	Long Cr (2), Phipps Meadow (1), Middle Fork between Ragged Cr and Phipps Meadow (1), Flood Meadow (2), Keeney Meadow (2), Camp Cr (1) Coxie Meadow (2)	Degraded floodplain, altered hydrology	Removal of wetlands	Abundance, productivity	Primarily, fry and 0+	
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	Upper mainstem Middle Fork from Big Cr upstream to Idaho Cr (2), Lower Vinegar (2), Vincent (2), and Long crs (1), Camp Cr (1), Placer Gulch (1), Davis Cr (1), Indian Cr (2)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity, spatial structure	Primarily, fry and 0+	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain to channel	ODFW, watershed council, SWCD, USFS, BLM	Ongoing	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Reconnect side channels and off-channel habitats to stream channels	ODFW, watershed council, SWCD, USFS, BLM, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, because of widespread need	5-15 years, depending upon frequency and duration of channel altering flows	Moderate, depending upon how extensive the project is and frequency and duration of channel altering flows
Restore wet meadows	TNC, USFS, CTWSRO	Ongoing and planned	Benefits of improved channel morphology localized, improved water table and resulting increased stream flow and lower water temperatures have high dispersal downstream	Intermediate	5-15 years	Moderate
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	ODFW, CTWSRO, USFS, BLM	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, due to acceptance by landowners and widespread need	Within 5 years once the dams are built	Moderate-high, dependent upon acceptance by landowners

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Private lands throughout the MF watershed, Phipps Meadow, Rush Creek, and Eightmile Creek	No	Program limited primarily by funding.

Strategy 3. Maintain and restore floodplain connectivity and function.				
USFS/BLM	Stream enhancement program	Federal lands, Middle Fork John Day, Summit Creek. Only when specifically identified that passive restoration is not working.	Yes in some areas, no in others due to limited funding	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	Private lands throughout the MF Watershed, Rush Creek has been specifically identified	Uncertain	Active restoration only if specific needs cannot be addressed by passive restoration techniques, need additional resources.
Soil and Water Conservation Districts	Watershed restoration	Private lands throughout the MF Watershed		See State of Oregon programmatic review -- Appendix F.
Nature Conservancy and other NGOs	Restoration projects	TNC Middle Fork Preserve and conservation easement on RPB property	Yes where applied	Program could expand to other priority areas.
CTWRSO	Watershed restoration	Oxbow and Forrest Ranch properties	Likely	Program could expand.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Instream activities have not been identified as a high priority by the recovery planning team or the subbasin plan team except when identified as a need for specific sites. The planning team prefers that more passive approaches, such as riparian and upland improvements be emphasized. Typically, instream activities would include placement of rootwads, whole trees, or boulder clusters to improved habitat complexity and habitat diversity where those parameters are deficient and not expected to improve with passive restoration. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Upper mainstem Middle Fork from Big Cr upstream to Idaho Cr (1), Lower Vinegar (2), Vincent (2), and Long (2) crs Channel reconfiguration work needed: mouth of Granite Boulder Cr to Ragged Cr (1), between Big Boulder Cr and Camp Cr (1), between Elk Cr and Bear Cr (2), and near the mouth of Mosquito Cr (1); Rush Cr (2)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature, flows	Stream channelization, bank armoring, large wood removal, beaver removal, removal of riparian vegetation, livestock overgrazing in riparian areas	Abundance, productivity	Primarily, fry and 0+	Passive restoration techniques, such as riparian fencing, are the preferred method for improving channel structure and stability. More active restoration techniques may be appropriate in these reaches. Historical dredge mining in several reaches of the mainstem Middle Fork between Caribou Cr and Mosquito Cr has simplified the stream channel. The North Fork Watershed Council is working with a landowner to restore channel sinuosity on Rush Cr.
Place stable wood and other large organic debris in	Upper mainstem Middle Fork from Big Cr upstream to Idaho Cr (1), Lower Vinegar (2),	Degraded channel structure and complexity,	large wood removal channelization	Abundance, productivity	Primarily, fry and 0+	More active restoration techniques, such as rootwad placement or channel

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
streambeds and in floodplains	Vincent (2), and Long (2) crs; Big Boulder Cr (1), Rush Cr (2)	habitat diversity, sediment routing, water temperature				reconfiguration, may be appropriate in these reaches.
Stabilize streambanks	Upper mainstem Middle Fork from Big Cr upstream to Idaho Cr (1),Lower Vinegar (2), Vincent (2), and Long (2) crs	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily eggs, fry and 0+	Some bank erosion is inevitable and beneficial. However, where erosion is actively taking place due to unnatural processes, stabilization may be needed to reduce fine sediments

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, USFS, BLM, watershed councils	Ongoing and planned	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Place stable wood and other large organic debris in streambeds and in floodplains	ODFW, USFS, watershed councils, BLM, SWCDs	As needed	For the immediate stream reach	Once identified, short term	Immediate	High
Stabilize streambanks	ODFW, USFS, watershed councils, BLM, SWCDs	Ongoing	For the treated stream reach, physical benefits dispersed downstream	Passive stabilization techniques are preferred and take longer to implement	With passive restoration the response may take 15 years	Medium to high, depending upon the extent of the treatments

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Big Boulder Creek and those specifically identified as deficient in habitat diversity	No	Program could expand, approach sufficient.
USFS, BLM	Stream enhancement program	Those streams specifically identified as deficient in habitat diversity	Yes in some areas, no in others due to limited funding	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	Those streams specifically identified as deficient in habitat diversity	Uncertain	Restricted by resources, approach sufficient.
Soil and Water Conservation Districts	Watershed restoration	Those streams specifically identified as deficient in habitat diversity		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Big Boulder Creek and those specifically identified as deficient in habitat diversity	Uncertain	Scope of program limits success, approach sufficient.
NGOs	Watershed restoration	TNC Middle Fork Preserve and RPB conservation easement property	Uncertain	

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Instream activities have not been identified as a high priority by the recovery planning team or the subbasin plan team except when identified as a need for specific sites. The planning team prefers that more passive approaches, such as riparian and upland improvements be emphasized. Typically, instream activities that would improve floodplain function and channel migration processes would include placement of rootwads, whole trees, or boulder clusters to improved habitat complexity and habitat diversity where those parameters are deficient and not expected to improve with passive restoration. Another structural activity would be to construct boulder or log weirs to raise the water table, but only where a passive approach has not worked.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.
The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategic Actions and Impacts on Limiting Factors, Threats, and Population

Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	Mainstem Middle Fork John Day between Crawford and Bridge crs (1), between Horse and Camp crs (1), below Highway 395 (2); and Long (1), Slide (2), Eightmile (2), Sixmile (2), Twelvemile (2), Granite (2), Camp (!), and Crawford (2) crs	Degraded riparian area, channel structure and complexity, floodplain degradation, altered hydrology, sediment, water quality	Overgrazing of riparian area, channelization, stream bank armoring, tree harvest in riparian areas, changes in plant communities (including invasive plants), loss of beaver dams	Abundance, productivity	Primarily fry and 0+	Primary methods of riparian enhancement include riparian corridor fences to exclude livestock, changes in grazing management that promote riparian recovery, and planting of native shrubs.
Develop grazing strategies that promote riparian recovery	Mainstem Middle Fork John Day between Crawford and Bridge crs (1), between Horse and Camp crs (1), below Highway 395 (2); and Long (1), Slide (2), Eightmile (2), Sixmile (2), Twelvemile (2), Granite (2), Camp (!), and Crawford (2) crs	Same as above	Livestock overgrazing of riparian area	Abundance, productivity	Primarily fry and 0+	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities including vegetative planting	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, (see above)	High, based upon experience with existing grazing management and riparian recovery projects
Develop grazing strategies that promote riparian recovery	NRCS, AFS, USFS, BLM, SWCDs, ODFW, Watershed Councils, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, depending upon grazing plan adopted. Riparian corridor fencing and removal of riparian grazing has the fastest recovery rate.	High, based upon experience with existing grazing management and riparian recovery projects

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Big Boulder Creek, MF John Day,	No	Program limited by funding.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.				
		Phipps Meadow		
SWCDs	Upland improvements, riparian improvements	Private lands throughout the watershed		Could be expanded.
Watershed Councils	Upland improvements, riparian improvements	Eightmile and Rush Creek, and others as later identified	No	Limited by resources, approach sufficient.
USFS/BLM	Upland improvements, riparian improvements	Federal lands, Long Creek specifically identified	Uncertain	Funding is limited. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
NRCS	Upland improvements, riparian improvements	Private lands as identified by SWCD and Watershed Council	Yes	Program sufficient.
ODA	Agricultural Water Quality Management Program	Private lands, specifically Granite Creek		See State of Oregon programmatic review -- Appendix F.
CTWRSO	Watershed restoration	Oxbow and Forrest Ranch properties	Likely where implemented	Program could be implemented on broader scale.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
See discussion for Strategy 5, Lower Mainstem John Day River population. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management program remains challenging in some locations.				

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	Long Cr and its tributaries (1); Mainstem Middle Fork, Coyote Cr. to Camp Cr. (2)	Altered hydrology, low flows, high temperatures	Water withdrawals, land conversion on uplands, road network	Abundance, productivity	Fry and 0+	Most other sections of the Middle Fork with consumptive water rights are now under conservation agreements.
Improve irrigation conveyance and efficiency	Long Cr and its tributaries (1); Mainstem Middle Fork, Coyote Cr. to Camp Cr. (2)	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Fry and 0+	
Increase pool habitat (beaver ponds)	Long Cr and its tributaries (1), Camp (1), Crawford (1), Deerhorn (2), Davis (2), Placer Gulch (2), Granite (1), Rush (2), Twelvemile (2), Slide (1), Sixmile(2), Squaw (1), Idaho (1), Lick (2), Mainstem Middle Fork, Coyote Cr. to Camp Cr. (2)	Altered hydrology, low flows, high temperatures	Loss of wet meadows	Abundance, productivity	All freshwater life stages	
Floodplain aquifer recharge	Granite Boulder Cr (1)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	Pilot project with CTWSRO.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Lease or acquire water rights and convert to instream	Long Cr. and its tributaries (2); Mainstem Middle Fork, Coyote Cr. to Camp Cr. (1)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	Annual fluctuations in flow levels are intensified by irrigation withdrawals.
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD, watershed councils, NRCS	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights.
Improve irrigation conveyance and efficiency	SWCD, OWEB, watershed councils, NRCS, landowners	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights.
Increase pool habitat (beaver ponds)	SWCD, ODFW, CTWSRO, USFS	Ongoing	High dispersal downstream	Unknown	Immediate increase in instream flow	High
Floodplain aquifer recharge	CTWSRO, SWCDs	Planned, some ongoing	Potentially high dispersal from recharge project site downstream for many miles	Long term, although opportunities for pilot projects is dependent upon willing landowner	Immediate	High, if the additional water is protected from being appropriated to a downstream user in areas with instream water rights.
Lease or acquire water rights and convert to instream	OWRD, FSA, OWEB, Oregon Water Trust, others	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and highly dependent upon landowner willingness to lease.	Immediate	High, if the leased water is protected from being appropriated to a downstream user in areas with instream water rights. FSA pays higher rates for CREP enrollment when water rights are leased for instream use.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion downstream to mouth of John Day River	Long term, dependent upon OWRD enforcing the requirement to measure water usage	Immediate	High if water user reporting requirement and installation of measuring devices on diversions is implemented.
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program, riparian improvements	Camp Creek, Phipps Meadow, Oxbow property	No	Limited by funding, approach sufficient.
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Where irrigation withdrawals occur throughout the MF John Day watershed		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust and BOR	Leasing and Purchase of Water Rights	Middle Fork John Day, Vinegar and Clear creeks	No	Program limited by funding.
Soil and Water Conservation Districts	Improve irrigation efficiency, upland improvements, riparian improvements	Middle Fork John Day, Vinegar and Clear creeks		See State of Oregon programmatic review -- Appendix F.
Watershed Councils	Upland improvements, riparian improvements	Rush and Eightmile creeks	No	Limited resources.
NRCS	Upland improvements, riparian improvements	Those identified by SWCD and Watershed Council	No	Limited resources.
CTWSRO	Watershed restoration	Oxbow and Forrest Ranch properties	Likely in areas of implementation	Program could expand.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Approximately 66 miles of stream in the Middle Fork are protected with either existing or pending instream water rights. The instream water rights do not preclude further appropriation of water until flows in the affected reach drop down to the instream water rights as adopted by OWRD. Voluntary efforts restored 5.7 cfs instream in 2006.

The Oregon Water Trust has made good progress at restoring flows in the Middle Fork with a total of over 20 cfs of water being converted to instream flow and water leases for another approximately 11 cfs on various streams throughout the subbasin.

See Strategy 6, Lower Mainstem John Day River population for further discussion.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Increase riparian shading	Mainstem: between Crawford and Caribou crs (1), between Tincup and Ragged crs (1), between Balance and Camp crs (1), below Highway 395 (2); Long Cr and tributaries (1); Indian Cr (2), Twelvemile (2), Sixmile (2) and Slide (2) crs	High water temperatures	Degraded riparian forests	Abundance, productivity	Fry and 0+	Elevated water temperatures are the result of reduced riparian vegetation and loss of floodplain function (wet meadow storage). Elevated water temperature is a pervasive water quality problem for the Middle Fork John Day River population, with 21 stream reaches listed as water quality limited. Additional reaches would probably be listed is water temperature data were available.
Manage return flow to reduce extreme stream temperatures	Mainstem: between Highway 7 and Caribou Cr (1), and between Horse and Camp crs (2); Long Cr (1)	High water temperatures	Water withdrawals	Abundance, productivity	Fry and 0+	
Reduce chemical pollution and nutrient inputs	None identified at this time	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity	Fry and 0+	Using more efficient irrigation methods should result in fewer nutrients from pastures reaching the John Day River. Although the Middle Fork has been extensively impacted by historical mining activity, there are no known contamination issues.
Apply BMPs to animal feeding operations	Granite Cr (1)	Degraded water quality	Animal feed operations	Abundance, productivity	Fry and 0+	
Continue TMDL monitoring	For sediment: Mainstem Middle Fork above Camp Cr (2), Long Cr and tributaries (1), Butte Cr (2), Indian Cr (2), and Slide Cr (2). For temperature: Mainstem: between Highway 7 and Caribou Cr (1), below Camp Cr (2); Long Cr (1); Indian Cr (2)	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	Eggs, fry, juveniles, adults	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Increase riparian shading	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years	High
Manage return flow to reduce extreme stream temperatures	SWCDs, watershed councils	Ongoing	Water quality improvement would have high dispersal downstream	Less than 5 years, once the project has been identified	Immediate	High, reduced temperatures has been well documented

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Reduce chemical pollution and nutrient inputs	ODEQ, others	Ongoing	High dispersal downstream	Ongoing	Reduce chemical pollution immediately	High
Apply BMPs to animal feeding operations	ODA	Ongoing	Water quality improvement would have high dispersal downstream	Some treatments could be done immediately. There are few animal feeding operations within the subbasin, only one of which has been identified as a problem	5-15 years	High, once a treatment has been agreed upon
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA	CREP, CRP	Middle Fork John Day, Granite Creek	No	Yes
ODEQ	Mine Waste Program	None currently identified, although extensive mining activity occurred on Middle Fork and tributaries		See State of Oregon programmatic review -- Appendix F.
ODA	Confined animal feeding operations (CAFO), AgWQM	Granite Creek, others as later identified		See State of Oregon programmatic review -- Appendix F.
ODEQ, ODA, SWCD, USFS	Sedimentation Monitoring (TMDL Development and Implementation)	Throughout the Middle Fork watershed		See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Low streamflows during the hottest part of the year exacerbate the already warm water temperatures. Opportunities for increasing streamflow through leasing of water rights, which often results in cooler water over a longer stream reach, are being pursued by Oregon Water Trust and US Bureau of Reclamation. Constraints for future projects include acceptance by landowners and a secure, long term funding source.

The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Reducing water temperatures through the use of improved riparian vegetation and more efficient methods of irrigation may take several years to provide measurable results. Many projects that improve water quality by reducing irrigation return water have been completed.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore native upland plant communities	MaSAs; Middle Fork and north side tributaries below Highway 395 (1), Long Cr (1), Slide Cr (2)	Altered hydrology, sediment routing, channel stability, floodplain and riparian area	Upland land use practices, loss of water storage	Abundance, productivity	Fry and 0+	Upland improvements such as restoring native plant communities and controlling invasive weed species will improve

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
		degradation, water quality	capacity			precipitation infiltration rates and ultimately improve watershed health, including the hydrograph.
Upgrade or remove problem forest roads	Forest lands, 46 miles on Camp Cr and five miles on the Upper MF have been identified for treatment	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Road network	Abundance, productivity	Fry and 0+	
Initiate upland improvement demonstration projects	None identified	Same as above	Upland land use practices	Abundance, productivity	Fry and 0+	
Manage vegetation, including juniper removal	Middle Fork and north side tributaries below Highway 395 (1), Long Cr (1), Slide Cr (2)	Altered hydrology, sediment routing	Invasive plants	Abundance, productivity	Fry and 0+	
Demonstration projects to restore forest health and resilience to wildfire	Private and forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to forest practices including fuels management and fire suppression mitigation; livestock grazing; roads; and agricultural practices	Middle Fork and north side tributaries below Highway 395 (1), Long Cr (1), Slide Cr (2)	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	Fry and 0+	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore native upland plant communities	SWCD, USFS, BLM	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term	5-15 years	Moderate, depending upon which treatments are used to restore native plant communities, and whether appropriate short term restrictions on grazing are adopted
Upgrade or remove problem forest roads	USFS, ODF, ODOT	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff. Decommissioning may take many years	15 years	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Initiate upland improvement demonstration projects	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed
Manage vegetation, including juniper removal	USFS, BLM, NRCS, SWCDs, Watershed Councils	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Juniper control can be done quickly, other strategies such as control of invasive plants may take more than 20 years	5-30 years	Moderate

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to forest practices including fuels management and fire suppression mitigation; livestock grazing; roads; and agricultural practices	SWCD, USFS, ODA, CTWSRO, BLM, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of Agricultural Water Quality Management Plans	0-20,years, depending upon treatments applied	Moderate, dependent upon voluntary landowner participation

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS/Farm Service Agency	CRP	Long Creek, Basin Creek	No	Program needs expansion.
SWCDs	Juniper control	Long Creek, Basin Creek	No	More areas need treatment, rate of treatment restrictive.
ODFW	Green Forage	Long Creek, Basin Creek	No	Very small program.
USFS/BLM	Forest Plan, PACFISH, Resource Management Plan	Federal lands within the Middle Fork watershed	Uncertain	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
ODA	Agricultural Water Quality Management Program	Private lands within the Middle Fork watershed		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Oxbow and Forrest Ranch properties	Likely where implemented	Could be expanded.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

See Strategy 8, Lower Mainstem John Day River population for further discussion.

The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Implementation of PACFISH standards and guides for Forest and BLM programs, has been highly successful for passive upland restoration over most of this population's area.

9.3.8 Habitat Strategies and Actions for South Fork John Day River Steelhead Population

Primary limiting factors: altered sediment routing, degraded channel structure and complexity (habitat quantity and diversity), altered hydrology and low flow, water temperature, and impaired fish passage.

Primary threats: riparian disturbance, stream channelization and relocation, grazing, forest practices, road building, fish passage barriers (culverts, and other seasonal barriers), and irrigation withdrawals.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition or conservation easements	Lower Murderers Cr tributaries draining the south side of Aldrich Mountain: Todd (1), Cabin (1), Dry Cabin (1), Duncan (1) and Dry Duncan (1); Black Canyon Cr (1); mainstem South Fork, north boundary of PW Schneider WMA to Izee Falls (2)	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing,	Many threats including livestock overgrazing of riparian area, channelization, stream bank armoring, agricultural practices (fertilizers, herbicides, sediments, changes in plant communities), water withdrawals, loss of beaver dams	Productivity, abundance	Primarily fry and 0+	Protecting base streamflows from further appropriations is a very important function of protecting existing high quality habitats. Protection of high quality habitats is the most cost effective way of ensuring fish have good quality habitat. Land acquisitions, easements, and cooperative agreements may also facilitate the implementation of active restoration projects.
Adopt and manage Cooperative Agreements	South Fork, north boundary of PW Schneider WMA to Dayville (1); South Fork above Izee Falls (2)	Same as above	Same as above	Productivity, abundance	Primarily fry and 0+	
Special management designations in forest and BLM plans	Public lands as identified in Forest Plan Revision	Same as above	livestock overgrazing of riparian area, changes in plant communities	Productivity, abundance	Primarily fry and 0+	
Designate additional wilderness and wild and scenic status	Public lands identified as meeting the criteria during the Forest Plan Revision process	Same as above	livestock overgrazing of riparian area, changes in plant communities	Productivity, abundance	Primarily fry and 0+	
Protect access to key habitats	Black Canyon Cr (1)	Passage barriers, altered hydrology, channel structure		ivity, abundance, distribution	Primarily fry and 0+	Thoroughly review projects that may block fish passage. Current ODFW policy is to grant exemptions from fish passage requirements only if mitigation meets or exceeds the loss of habitat. Exemptions must be approved by the Fish and Wildlife Commission

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	Population-wide	All	Same as above	Productivity, abundance	Primarily fry and 0+	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements	CTUIR, TNC, RMEF, John Day Basin Trust, SWCDs, CTWSRO, USFS, ODFW	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5-15 years with passive restoration approaches	High, based on previous cooperative agreements
Adopt and manage Cooperative Agreements	ODFW, SWCDs, FSA	Ongoing	Same as above	Agreements are for 10 to 15 years	Immediate	High, although not in perpetuity
Special management designations in forest and BLM plans	USFS, BLM	Ongoing as identified	Same as above	Many complete, potentially subject to change in Forest Plan revisions	Immediate	High, although subject to change from Forest Plan or mgmt plan revision
Designate additional wilderness and wild and scenic status	Public lands identified as meeting the criteria in the Forest Plan Revision process and BLM Resource Management Plan revision.	Same as above	livestock overgrazing of riparian area, changes in plant communities	Immediate depending on socio-political acceptance	5-15 years	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	NRCS, SWCDs, USFS, ODFW, ODF, DSL, BLM, ODOT, CTWSRO, ODA, FSA, private landowners	Ongoing	Population-wide	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS, BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management designations, PACFISH	Black Canyon, SF Wild and Scenic Corridor, and other FS and BLM lands	Yes, PACFISH standards are good, but implementation is inconsistent between forests. See discussion below.	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW	Cooperative Agreements and PW Schneider Wildlife Management Area	Murderers Creek, SF John Day between Murderers Cr and Dayville, Upper SF on private lands	No	The agreements are for only 10-15 years and need to be for longer time periods.
FSA	CREP	Upper SF John Day	No	The agreements are for only 10-15 years and need to be for longer time periods.
NGOs	Lease or purchase of lands or instream water rights	None currently identified	Yes, although limited by acceptance from landowners	Important to secure critical habitat and/or water rights when opportunities arise.
ODA	Agricultural Water Quality Management Program	Private lands, primarily in upper SF (above Izee Falls)		See State of Oregon programmatic review -- Appendix F.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
CTWSRO	Watershed Restoration	Upper SF in cooperation with SWCD	Yes	Funding uncertain.
ODF	Oregon Forest Practices Act	Private and state owned timberlands	Likely	See State of Oregon programmatic review -- Appendix F.
Local Government	City and County Planning and Zoning	Private lands	Likely, riparian setbacks are sufficient when enforced	Monitoring of compliance needs to be increased.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Federally designated Wild and Scenic River reaches include the South Fork John Day River from Smokey Cr (RM 6.5) to the Malheur National Forest boundary (RM 52.5). State designated reaches include the South Fork from the PW Schneider Wildlife Management Area Boundary (RM 5.5) to County Road 63 (RM 35). Although wild and scenic designation does not preclude development, it requires development to be consistent with protecting the ORVs for which the river was designated, requires review of any activity that may affect ORVs within the ¼ mile river corridor, and protects the free flowing condition of the river. Designation as W&S essentially precludes construction of any major dam. A Management Plan was adopted by BLM and Oregon State Parks Department in 2001 for the designated rivers segments. Implementation of all the actions identified in the plan will likely take many years; however, grazing management plans for most of the allotments within corridor are complete. BLM allotment plans are complete.

One of the reasons for purchase of ODFW's Philip W. Schneider Wildlife Management Area in the South Fork John Day River subbasin was for its value as a steelhead spawning and rearing area. The mixture of BLM and ODFW owned lands, along with the adjoining Malheur National Forest lands are under a Coordinated Resource Management Plan (CRMP). The mainstem South Fork John Day River, which runs through the CRMP lands, has shown remarkable riparian recovery in the last 30 years, with 100% canopy closure on some reaches. Unfortunately several of the tributaries have not benefited as much from the same management strategy.

Wilderness designation essentially prevents any development and offers the greatest opportunity for protection of high quality habitat. Wilderness areas within the South Fork population boundary include, Black Canyon Wilderness (13,400 acres). Other special designated areas include the Utley Butte and Dry Cabin wildlife emphasis areas.

Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management programs remains challenging in some locations.

See Strategy 1, Lower Mainstem John Day River population for further discussion.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	**Geographic Locations (1-first priority, 2-second priority)**	**Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Remove or minimize use of push up dams	South Fork John Day River mainstem (1); Wind Cr (2)	Impaired fish passage	Push up dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Push up dams in the South Fork mainstem are scheduled for replacement within the next year. Annual maintenance and construction of push up dams contributes to onsite and downstream channel stability, loss of pools and other structure, and increased sediment loads.
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	Culverts on Deer, Murderers (1), SF Murderers (2), Tex (1) and Thorn (2) crs; head cut on SF Murderers Cr (1) A total of 74 culverts need replacement (see Appendix G).	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	
Construct ladders over existing permanent concrete or earth fill dams	None identified below Izee Falls	Impaired fish passage	Dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Provide screening at 100% of irrigation diversions	South Fork below PW Schneider boundary (1)	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry	All known diversions in the drainage area currently screened.
Replace screens that do not meet criteria	South Fork John Day River (1)	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry	Most irrigation diversions are in the Upper John Day drainage and it has been the major emphasis for replacement of screens not meeting criteria.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove or minimize use of push up dams	SWCD	Ongoing	Provide access to upstream habitat	Ongoing, but all push up dams not expected to be corrected for at least 15 years	Immediate	High, if comply with fish passage design criteria
Remove or replace barriers blocking passage -- dams, road culverts and irrigation structures	USFS, BLM, watershed councils, SWCDs, ODOT	Ongoing	Access to upstream habitat	Ongoing, replacing all culverts blocking fish passage expected to take 50 years (see Appendix G)	Immediate	High, if comply with fish passage design criteria
Construct ladders over existing permanent concrete or earth fill dams	ODFW, SWCDs	Ongoing	Provide access to upstream habitat	Ongoing, providing passage at all diversion and pond barriers will take many years (none below Izee falls)	Immediate	High if comply with fish passage design criteria
Provide screening at 100% of irrigation diversions	ODFW, SWCDs	Ongoing	At point of diversion	No screening currently needed	Immediate	High if comply with fish passage design criteria
Replace screens that do not meet criteria	ODFW	Ongoing	At point of diversion	Approximately four screens need to be replaced	Immediate	High if comply with fish passage design criteria

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Soil and Water Conservation Districts	Irrigation dam improvements, culvert replacement or retrofits	Private land on SF John Day and tributaries below Izee Falls		The Grant Soil and Water District is constrained by the construction window of opportunity. See State of Oregon programmatic review -- Appendix F.
ODFW	Fish Passage/Screening	Private and state owned lands on SF John Day and tributaries below Izee Falls	Likely	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding. No screen upgrades currently identified.
USFS, BLM	Culvert replacement	Federal lands, BLM previously corrected the Smokey Creek culvert. The BLM has no adult barriers at culverts. Monitoring is needed to determine if upstream passage for juveniles is an issue.	Uncertain	Slow pace will take 50 years to complete. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Road Crossing Passage improvements, passage improvements	Private land on SF John Day and tributaries below Izee Falls	No	Program needs expansion.
BOR	John Day Basin Program	Private land on SF John Day and tributaries below Izee Falls	Yes	No

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.				
CTWSRO	John Day Basin Program	Private land on SF John Day and tributaries below Izee Falls in cooperation with SWCD	No	The tribe contracts with Soil and Water Districts to assist with consultation, permits, and monitoring, program needs additional resources.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
See discussion in Strategy 2, Lower Mainstem John Day River population. Most of the mainstem passage problems have been addressed, but there are many tributaries where adult passage is blocked and more areas where juvenile passage problems occur. Soil and Water Districts are correcting passage at irrigation diversions and improperly installed culverts, but are constrained by funding and by personnel needed for construction oversight. An inventory of road crossings on state and county roads in 1999 indicated no culverts on state owned roads and 10 culverts on county owned roads did not meet fish passage criteria within the South Fork population boundary. Appendix G presents an inventory of culverts with known passage problems on state or county owned roads. The US Forest Service and BLM are constrained primarily by funding and the personnel needed for NEPA analysis. At the current rate of culvert replacements it will take over 50 years to correct all passage problems on National Forests, however the Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) provides guidance that will help prioritize culvert replacements for this population. The BLM has no adult barriers at culverts. Monitoring is needed to determine if upstream passage for juveniles is an issue.				

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Murderers Cr, Chickenhouse Gulch to Todd Cr (2); South Fork mainstem, Izee Falls upstream to Malheur NF boundary (1)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily, fry and 0+.	The upper South Fork from Indian Cr upstream to the Malheur NF boundary is no longer connected to its floodplain and is deeply incised. Although this is above steelhead distribution, it would have substantial benefits to steelhead rearing in the SF below Izee Falls.
Reconnect side channels and off-channel habitats to stream channels	Murderers Cr, Chickenhouse Gulch to Todd Cr (2); South Fork mainstem, Izee Falls upstream to Malheur NF boundary (1)	Degraded floodplain, altered hydrology	Removal of side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity, spatial structure	Primarily, fry and 0+.	There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows.
Restore wet meadows	SF Murderers (1); Murderers (2); Upper Deer Cr. (1)	Degraded floodplain, altered hydrology	Removal of wetlands	Abundance, productivity	Primarily, fry and 0+.	
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	Murderers Cr, Chickenhouse Gulch to Todd Cr (2); South Fork mainstem, Izee Falls upstream to Malheur NF boundary (1); SF Murderers (1); Wind (2); and Deer (1) crs	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity, spatial structure	Primarily, fry and 0+.	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain to channel	ODFW, watershed council, SWCD, USFS, BLM	Ongoing	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High

Strategy 3. Maintain and restore floodplain connectivity and function.						
Reconnect side channels and off-channel habitats to stream channels	ODFW, watershed council, SWCD, USFS, BLM, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, because of widespread need	5-15 years, depending upon frequency and duration of channel altering flows	Moderate, depends on how extensive the project is and frequency and duration of channel altering flows
Restore wet meadows	TNC, USFS, CTWSRO	Ongoing and planned	Benefits of improved channel morphology localized, improved water table and resulting increased streamflow and lower water temperatures have high dispersal downstream	Intermediate	5-15 years	Moderate
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	ODFW, CTWSRO, USFS, BLM	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, due to acceptance by landowners and widespread need	Within 5 years once the dams are built	Moderate-high, depends upon acceptance by landowners

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Private and state owned lands on SF John Day above Izee Falls, SF John Day below Izee Falls, Murderers Cr	No	Sufficient approach, resource limited.
USFS, BLM	Stream enhancement program	SF John Day and tributaries above and below Izee Falls on Federal land. Only when specifically identified that passive restoration is not working.	Yes in some areas, no in others	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. May need expansion. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	Private lands on SF John Day and tributaries above Izee Falls	Uncertain	Active approaches only if specific needs cannot be addressed by passive restoration techniques.
Soil and Water Conservation Districts	Watershed restoration	Private lands on SF John Day and tributaries above and below Izee Falls		Active approaches only if specific needs cannot be addressed by passive restoration techniques.
Nature Conservancy and other NGOs	Restoration projects	None currently identified	Uncertain	Needs expansion.
CTWSRO	Watershed restoration	Private lands in SF John Day and tributaries above and below Izee Falls in cooperation with SWCD and Watershed Council	Likely	Could be expanded to other areas.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategic Actions and Impacts on Limiting Factors, Threats, and Population

Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Murderers Cr, Chickenhouse Gulch to Todd Cr (2); South Fork mainstem, Izee Falls upstream to Malheur NF boundary (1)	Degraded channel structure and complexity, habitat diversity, riparian area degradation, connectivity with floodplain, sediment routing, water temperature, flows	Stream channelization, bank armoring, large wood removal, beaver removal, removal of riparian vegetation, livestock overgrazing in riparian areas	Abundance, productivity	Primarily eggs, fry and 0+.	The upper South Fork from Indian Cr upstream to the Malheur NF boundary is no longer connected to its floodplain and is deeply incised.
Place stable wood and other large organic debris in streambeds and in floodplains	Murderers Cr, Chickenhouse Gulch to Todd Cr (1); South Fork mainstem, Izee Falls upstream to Malheur NF boundary 92); Deer (1); SF Murderers (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	large wood removal channelization	Abundance, productivity	Primarily eggs, fry and 0+.	More active restoration techniques, such as rootwad placement or channel reconfiguration, may be appropriate in these reaches. Typical structures include rootwads, boulder clusters, whole trees, and rock weirs where appropriate.
Stabilize streambanks	South Fork mainstem from Izee Falls upstream to Malheur NF boundary (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily eggs, fry and 0+.	Some bank erosion is inevitable and beneficial. However, where erosion is actively taking place due to unnatural processes, stabilization may be needed to reduce fine sediments

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, USFS, BLM, watershed councils	Ongoing and planned	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Place stable wood and other large organic debris in streambeds and in floodplains	ODFW, USFS, watershed councils, BLM, SWCDs	As needed	For the immediate stream reach	Once identified, short term	Immediate	High
Stabilize streambanks	ODFW, USFS, watershed councils, BLM, SWCDs	Ongoing	For the treated stream reach, physical benefits dispersed downstream	Passive stabilization techniques are preferred and take longer to implement	With passive restoration the response may take 15 years	Medium to high, depending upon the extent of the treatments

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	None currently identified.	No	When specific needs cannot be addressed by passive restoration techniques.
USFS, BLM	Stream enhancement program	Deer, Wind and Murderers creeks on Federal lands, but only	Yes in some areas, no in others	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.				
		when specifically identified as deficient in habitat diversity and that passive restoration is not working		processes. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	None currently identified.	Uncertain	Only if specific needs cannot be addressed by passive restoration techniques.
Soil and Water Conservation Districts	Watershed restoration	None currently identified.		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	None currently identified.	Uncertain	No opportunities currently identified.
NGOs	Watershed restoration	None currently identified.	Uncertain	No opportunities currently identified.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Instream activities have not been identified as a high priority by the recovery planning team or the subbasin plan team except when identified as a need for specific sites. The planning team prefers that more passive approaches, such as riparian and upland improvements be emphasized. Typically, instream activities that would improve floodplain function and channel migration processes would include placement of rootwads, whole trees, or boulder clusters to improved habitat complexity and habitat diversity where those parameters are deficient and not expected to improve with passive restoration. Another structural activity would be to construct boulder or log weirs to raise the water table, but only where a passive approach has not worked. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	mainstem South Fork John Day above Izee Falls (1); Murderers Cr between the lower USFS boundary up to Tex Cr (2); SF Murderers (1); Deer Cr, mouth to headwaters (1)	Degraded riparian area, channel structure and complexity, floodplain degradation, altered hydrology, sediment, water quality	Overgrazing of riparian area, channelization, stream bank armoring, tree harvest in riparian areas, changes in plant communities (including invasive plants), loss of beaver dams	Abundance, productivity	Primarily fry and 0+	Primary methods of riparian enhancement include riparian corridor fences to exclude livestock, changes in grazing management that promote riparian recovery, and planting of native shrubs.
Develop grazing strategies that promote riparian recovery	mainstem South Fork John Day above Izee Falls (1); Murderers Cr between the lower USFS boundary up to Tex Cr (2); SF Murderers (1); Deer Cr, mouth to headwaters (1)	Same as above	Livestock overgrazing of riparian area	Abundance, productivity	Primarily fry and 0+	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality	Long term because of widespread need	5-15 years	High, based upon experience with existing grazing

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
			benefits will have high dispersal downstream from site			management and riparian recovery projects
Develop grazing strategies that promote riparian recovery	NRCS, AFS, USFS, BLM, SWCDs, ODFW, Watershed Councils, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, depending upon grazing plan adopted. Riparian corridor fencing and removal of riparian grazing has the fastest recovery rate.	High, based upon experience with existing grazing management and riparian recovery projects

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Indian and Murderers creeks, SF John Day below Izee Falls	No	Limited by resources.
SWCDs	Upland improvements, riparian improvements	Private lands on SF John Day and tributaries above and below Izee Falls. Act ive program on SF above Izee Falls		See State of Oregon programmatic review -- Appendix F.
Watershed Councils	Upland improvements, riparian improvements	Private lands on SF John Day and tributaries above Izee Falls	No	Resource limited.
USFS, BLM	Upland improvements, riparian improvements	Federal lands on SF John Day and tributaries above and below Izee Falls. Murderers and Wind creeks	Likely	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
NRCS	Upland improvements, riparian improvements	Indian Creek, SF John Day above Izee Falls	Yes	Program sufficient.
ODA	Agricultural Water Quality Management Program	SF John Day above Izee Falls		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed restoration	Private lands on SF John Day and tributaries above and below Izee Falls in cooperation with SWCD and Watershed Council	Uncertain	Limited opportunities currently identified for this program.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

See discussion for Strategy 5, Lower Mainstem John Day River population.

In the last 20+ years ODFW, Watershed Councils, NRCS and Soil and Water Districts have implemented hundred of miles of riparian improvements on private lands, primarily through construction of riparian corridor fences that exclude livestock grazing, and development of off channel watering devices. Public land managers have implemented PACFISH standards for protection and restoration of USFS and BLM lands. Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management programs remains challenging in some locations. The Forest Services Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Primary constraints on implementing additional projects for more riparian improvements are funding and personnel needed for lanning, promotion, education of landowners, and implementation.

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Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	Mainstem South Fork John Day above Izee Falls (1); Murderers Cr between the lower USFS boundary up to Tex Cr (2); SF Murderers (1); Deer Cr, mouth to headwaters (1)	Altered hydrology, low flows, high temperatures	water withdrawals, land conversion on uplands, road network	Abundance, productivity	Primarily fry and 0+	The lower and upper mainstem South Fork John Day is used extensively for irrigation purposes, small diversions are present on Wind and Murderers crs
Improve irrigation conveyance and efficiency	South Fork John Day River below PW Schneider WMA boundary (1); Upper South Fork John Day River (1); Wind (2) and Murderers (2) crs	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Primarily fry and 0+	
Increase pool habitat (beaver ponds)	Lower South Fork John Day River (2); Upper South Fork John Day River (1); Wind (2); Deer (1); SF Murderers (1); and Murderers (1) crs	Habitat complexity		Abundance, productivity	Primarily fry and 0+	
Floodplain aquifer recharge		Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and 0+	
Lease or acquire water rights and convert to instream	Lower South Fork John Day River (2); Upper South Fork John Day River (1); Wind (2) and Murderers (2) crs	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and 0+	
Monitor/regulate water withdrawals	All MaSAs	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily fry and 0+	
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD, watershed councils, NRCS	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights
Improve irrigation conveyance and efficiency	SWCD, OWEB, watershed councils, NRCS, landowners	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of	Immediate	High, if the saved water is protected from being appropriated to a

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
				projects		downstream user in areas with instream water rights
Increase pool habitat (beaver ponds)	SWCD, ODFW, CTWSRO, USFS, BLM	Ongoing	High dispersal downstream	Unknown	Immediate increase in instream flow	High
Floodplain aquifer recharge	CTWSRO, SWCDs	Planned, some ongoing	Potentially high dispersal from recharge project site downstream for many miles	Long term, although opportunities for pilot projects is dependent upon willing landowner	Immediate	High, if the additional water is protected from being appropriated to a downstream user in areas with instream water rights
Lease or acquire water rights and convert to instream	OWRD, FSA, OWEB, Oregon Water Trust, others	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and highly dependent upon landowner willingness to lease.	Immediate	High, if the leased water is protected from being appropriated to a downstream user in areas with instream water rights. FSA pays higher rates for CREP enrollment when water rights are leased for instream use.
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion downstream to mouth of John Day River	Long term, dependent upon OWRD enforcing the requirement to measure water usage	Immediate	High if water user reporting requirement and installation of measuring devices on diversions is implemented
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program, riparian improvements	Private land on SF John Day above Izee Falls, private and state lands on Murderers and Indian creeks	No	Limited by resources.
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	SF John Day and tributaries where irrigation withdrawals occur		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust and BOR	Leasing and Purchase of Water Rights	None currently identified, dependent upon cooperating landowner	No	No program currently active.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Soil and Water Conservation Districts	Improve irrigation efficiency, upland improvements, riparian improvements	Private lands on SF John Day and tributaries above and below Izee Falls		Could increase in scope.
Watershed Councils	Upland improvements, riparian improvements	SF John Day above Izee Falls	No	Needs expansion.
NRCS	Upland improvements, riparian improvements	SF John Day above Izee Falls	No	Needs expansion.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Approximately 22 miles of stream in the South Fork are protected with either existing or pending instream water rights. The instream water rights do not preclude further appropriation of water until flows in the affected reach drop down to the instream water rights as adopted by OWRD. Voluntary efforts restored 0.6 cfs instream in 2006. See Strategy 6, Lower Mainstem John Day River population for further discussion.				

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Increase riparian shading	Upper South Fork and tributaries above Izee Falls (1); Lower South Fork near the town of Dayville (2); Deer (2); SF Murderers (1); Murderers (2) crs	High water temperatures	Degraded riparian forests	Abundance, productivity	Primarily fry and 0+	Elevated water temperature is a pervasive water quality problem for the South Fork John Day River population, with 6 stream reaches listed as water quality limited. Additional reaches would probably be listed if water temperature data were available.
Manage return flow to reduce extreme stream temperatures	Upper South Fork and tributaries above Izee Falls (1); Lower South Fork near the town of Dayville (2); Wind (2) and Murderers (1) crs	High water temperatures	Water withdrawals	Abundance, productivity	Primarily fry and 0+	
Reduce chemical pollution and nutrient inputs	Upper South Fork and tributaries above Izee Falls (1); Lower South Fork near the town of Dayville (2)	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity	Primarily fry and 0+	Using more efficient irrigation methods, which reduces the amount of surface water returning to the stream, should result in fewer nutrients from pastures reaching the South Fork John Day River and tributaries. Reducing nutrient loads will contribute to increased water quality by reducing biological oxygen demand and algae blooms.
Apply BMPs to animal feeding operations	South Fork John Day River above Izee Falls (1)	Degraded water quality	Animal feed operations	Abundance, productivity	Eggs, fry, juveniles	
Continue TMDL monitoring	Upper South Fork and tributaries above Izee Falls (1) Lower South Fork near the town of Dayville (2)	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	Primarily fry and 0+	

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Increase riparian shading	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years	High
Manage return flow to reduce extreme stream temperatures	SWCDs, watershed councils	Ongoing	Water quality improvement would have high dispersal downstream	Less than 5 years, once the project has been identified	Immediate	High, reduced temperatures has been well documented
Reduce chemical pollution and nutrient inputs	ODEQ, others	Ongoing		Ongoing	Reduce chemical pollution immediately	High
Apply BMPs to animal feeding operations	ODA	Ongoing	Water quality improvement would have high dispersal downstream	Some treatments could be done immediately. There are few animal feeding operations within the subbasin, only one of which has been identified as a problem	5-15 years	High, once a treatment has been agreed upon
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Subbasin-wide	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA	CREP, CRP	Private lands on SF John Day above Izee Falls	No	Could be expanded with additional funding.
ODA	Confined animal feeding operations (CAFO), AgWQM	SF John Day above Izee Falls		See State of Oregon programmatic review -- Appendix F.
ODEQ, ODA, SWCD, USFS	Sedimentation Monitoring (TMDL Development and Implementation)	Throughout SF John Day watershed		See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Low streamflows during the hottest part of the year exacerbate the already warm water temperatures. Opportunities for increasing streamflow through leasing of water rights, which often results in cooler water over a longer stream reach, are being pursued by Oregon Water Trust and US Bureau of Reclamation. Constraints for future projects include acceptance by landowners and a secure, long term funding source.

The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritization restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Reducing water temperatures through the use of improved riparian vegetation and more efficient methods of irrigation may take several years to provide measurable results. Many projects that improve water quality by reducing irrigation return water have been completed.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	**Geographic Locations (1-first priority, 2-second priority)**	**Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Restore native upland plant communities	South Fork mainstem above Izee Falls (1); Deer Cr (1); Murderers Cr (1)	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices, loss of water storage capacity	Abundance, productivity	Primarily fry and 0+	Upland improvements such as restoring native plant communities and controlling invasive weed species will improve precipitation infiltration rates and ultimately improve watershed health, including the hydrograph.
Upgrade or remove problem forest roads	Forest lands	Same as above	Road network	Abundance, productivity	Primarily fry and 0+	
Initiate upland improvement demonstration projects	South Fork mainstem above Izee Falls (1); Deer Cr (2); Murderers Cr (1)	Same as above	Upland land use practices	Abundance, productivity	Primarily fry and 0+	
Manage vegetation, including juniper removal	South Fork mainstem above Izee Falls (1); Deer Cr (2); Murderers Cr (1)	Altered hydrology, sediment routing	Invasive plants	Abundance, productivity	Primarily fry and 0+	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Throughout population	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	Primarily fry and 0+	

Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Restore native upland plant communities	SWCD, USFS, BLM	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term	5-15 years	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Upgrade or remove problem forest roads	USFS, ODF, ODOT	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff. Decommissioning may take many years	5-15 years	Moderate, although funding on public lands and landowner cooperation on private lands will

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
						determine rate of treatment
Initiate upland improvement demonstration projects	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed
Mange vegetation, including juniper removal	USFS, BLM, NRCS, SWCDs, Watershed Councils	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Juniper control can be done quickly, other strategies such as control of invasive plants may take more than 20 years	5-30 years	Moderate
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	SWCD, VSFS, ODA, CTWSRO, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of Agricultural Water Quality Management Plans	0-20,years, depending upon treatments applied	Moderate, dependent upon voluntary landowner participation

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS/Farm Service Agency	CRP	Private lands on SF John Day and tributaries above Izee Falls	No	Could be expanded.
SWCDs	Juniper control	Private lands on SF John Day and tributaries above and below Izee Falls		Could be expanded.
ODFW	Green Forage	Private lands on SF John Day and tributaries above Izee Falls, PW Schneider WMA	No	Very small program.
USFS, BLM	Forest Plan, PACFISH	Federal lands	Likely	See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review--Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review--Appendix F.
ODA	Agricultural Water Quality Management Program	Private lands on SF John Day and tributaries above and below Izee Falls		See State of Oregon programmatic review--Appendix F.
CTWSRO	Watershed Restoration	Private lands on SF John Day and tributaries above Izee Falls in cooperation with SWCD and Watershed Council	Uncertain	Currently limited in scope.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
See discussion for Strategy 8, Lower Mainstem John Day River population. NRCS, SWCD and ODFW programs are relatively small, with the CRP program the largest and best funded. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Implementation of PACFISH standards and guides for Forest and BLM programs has been highly successful for passive upland restoration over most of this population's area. The limitations to all the programs are funding and, to a lesser extent, acceptance by landowners.

9.3.9 Habitat Strategies and Actions for Upper Mainstem John Day River Steelhead Population

Primary limiting factors: degraded channel structure and complexity (habitat quantity and diversity), degraded riparian areas and LWD recruitment, altered sediment routing, water temperatures, altered hydrology and degraded floodplain function and connectivity. Impaired fish passage is also a priority limiting factor in Beech and Laycock creeks.

Primary threats: agricultural practices, overgrazing by livestock, removal of large trees from the riparian corridor, wetland draining and conversion, stream channelization and diking, mining, and dredging.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition or conservation easements	EF and Middle Fork of Canyon Cr (1), tributaries draining the north side of Strawberry Wilderness (2), upper McClellan Cr (tributary to John Day River) (2), McClellan Cr (tributary to EF Beech Cr) (2), upper Fields Cr (2), John Day River above Blue Mt. Hot Springs (1) and tributaries Rail (1), Roberts (1), Reynolds (1), Deardorff (1), and Call (1) crs.	Degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian area, altered hydrology, degraded water quality, altered sediment routing,	Many threats including livestock overgrazing of riparian area, channelization, stream bank armoring, agricultural practices (fertilizers, herbicides, sediments, changes in plant communities), water withdrawals, loss of beaver dams	Productivity, abundance	Primarily fry and 0+	Protecting base streamflows from further appropriations is a very important function of protecting existing high quality habitats. Protection of high quality habitats is the most cost effective way of ensuring fish have good quality habitat. Land acquisitions, easements, and cooperative agreements may also facilitate the implementation of active restoration projects.
Adopt and manage Cooperative Agreements	Grub Cr (2), John Day River between John Day and Blue Mt. Hot Springs (1), Indian Cr (2), Beech Cr (2), Cummings Cr (2), Canyon Cr (1)	Same as above	Same as above	Productivity, abundance	Primarily fry and 0+	
Special management designations in forest and BLM plans	Riparian Habitat Conservation Areas identified in existing Forest Plans	Same as above	Livestock overgrazing of riparian area, changes in plant communities	Productivity, abundance	Primarily fry and 0+	
Designate additional wilderness and wild and scenic status	Public lands identified in the Forest Plan Revision process	Same as above	Livestock overgrazing of riparian area, changes in plant communities	Productivity, abundance	Primarily fry and 0+	
Protect access to key habitats	Mainstem John Day River above Prairie City (1)	Passage barriers, altered hydrology, channel structure	Irrigation withdrawals, channelization	Productivity, abundance, distribution	Primarily fry and 0+	Thoroughly review projects that may block fish passage. Current ODFW policy is to grant exemptions from fish

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
						passage requirements only if mitigation meets or exceeds the loss of habitat. Exemptions must be approved by the Fish and Wildlife Commission.
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	Population-wide	All	Same as above	Productivity, abundance	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect the highest quality habitats through acquisition or conservation easements	CTUIR, TNC, RMEF, John Day Basin Trust, SWCDs, USFS, CTWSRO, ODFW	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5-15 years with passive restoration approaches	High, based on previous cooperative agreements
Adopt and manage Cooperative Agreements	ODFW, SWCDs, FSA	Ongoing	Same as above	Agreements are for 10 to 15 years	Immediate	High, although not in perpetuity
Special management designations in forest and BLM plans	USFS, BLM	Ongoing as identified	Same as above	Many complete, potentially subject to change in Forest Plan revisions	Immediate	High, although subject to change from Forest Plan or mgmt plan revision
Designate additional wilderness and wild and scenic status	Public lands identified in Forest Plan Revision	Same as above	livestock overgrazing of riparian area, changes in plant communities	Long term	Long term	High
Protect access to key habitats	ODFW, SWCD, Oregon Water Resources	Ongoing	Population-wide	Long term	Long term	Moderate
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	NRCS, SWCDs, USFS, ODFW, ODF, DSL, BLM, ODOT, CTWSRO, ODA, FSA, private landowners	Ongoing	Population-wide	Long term	5-15 years	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USFS, BLM	Wilderness Areas, Wilderness Study Areas, Wild and Scenic River corridors, Special Management designations, PACFISH	Strawberry Mt. Wilderness, scattered BLM parcels and Malheur National Forest	Yes, PACFISH standards are good, but implementation is inconsistent between forests. See discussion below.	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW	Cooperative Agreements	Private lands on John Day River above John Day, Grub, Indian, Beech, and Canyon crs	No	The agreements are for only 10-15 years and need to be longer.
FSA	CREP	Private lands on John Day River above Dayville, Indian and Beech crs	No	The agreements are for only 10-15 years and need to be longer.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
NGOs	Lease or purchase of lands or instream water rights	Private lands on John Day River and tributaries above Dayville. Current conservation agreements exist on Dry and Widows creeks	Yes	Important to secure critical habitat and/or water rights as opportunities arise.
ODA	Agricultural Water Quality Management Program	Private lands on John Day River and tributaries above Dayville		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Forrest Ranch and private lands in cooperation with SWCD	Likely	Expand as opportunities arise.
ODF	Oregon Forest Practices Act	State and private timberlands		See State of Oregon programmatic review -- Appendix F.
Local Government	City and County Planning and Zoning	Private lands	Uncertain	
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Federally designated Wild and Scenic River reaches include the mainstem John Day from Tumwater Falls (RM 10) to Service Cr (RM 157). State designated reaches include the mainstem John Day from Tumwater Falls to Parrish Cr (RM 170). Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management program remains challenging in some locations. The CTWSRO owns a mitigation property (3,365 acres) on the Mainstem John Day River above Prairie City that is managed for the benefit of fish and wildlife. See Strategy 1, Lower Mainstem John Day River population for further discussion.				

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Remove or minimize use of push up dams	Warrens (2), Bridge (2), Birch (2), Belshaw (2), Fields (1), Moon (2), McClellan (2), Beech (1), Canyon (1), Strawberry (1), Dixie (1), Isham (2), Dads (2), and Reynolds (1) crs.	Impaired fish passage	Push up dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Push up dams are most common in the Upper John Day and tributaries. Annual maintenance and construction of push up dams contributes to onsite and downstream channel stability, loss of pools and other structure, and increased sediment loads.
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	Irrigation or water storage related issues: Warrens (2), Bridge (2), Birch (2), Belshaw (2), Fields (1), Moon (2), McClellan (2), Beech (1), Canyon (1), Strawberry (1), Dixie (1), Isham (2), Dads (2), and Reynolds (1) crs Culverts: Canyon Cr and tributaries (1), Reynolds Cr (1), John Day River above Blue Mt Hot Springs (2), and Fields Cr (2) A total of 120 culverts have been identified in this population as needing replacement (see Appendix G)	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure	Primarily adults and 0+ juveniles	Push up irrigation dams, concrete diversions, in-channel stock ponds, and road culverts are located throughout the entire subbasin. Passage problems at culverts are widespread throughout all subbasins

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Construct ladders over existing permanent concrete or earth fill dams	Beech Cr (1)	Impaired fish passage	Dams	Abundance, productivity, spatial structure	Primarily adults and 0+juveniles	Concrete structures are located primarily in the Rock Cr. (Lower John Day) drainage although there are a number of structures scattered throughout other parts of the subbasin, including Beech Cr. and Reynolds Cr.
Provide screening at 100% of irrigation diversions	Dans (2), Jeff Davis (2), Strawberry (2), Pine (1), Ingles (2), Moon (1), Canyon (1), Cummings (1), Widows (2), Laycock (1) crs	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry, smolts	
Replace screens that do not meet criteria	Beech (1), Canyon (1), Dixie (2), Fields (1), Indian (1), Upper John Day River (1), Roberts (1) crs	Impaired fish passage	Irrigation diversions	Abundance, productivity, spatial structure	Emergent fry	Most migration diversions are in the Upper John Day drainage and it has been the major emphasis for replacement of non-criteria screens.

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove or minimize use of push up dams	SWCD	Ongoing	Provide access to upstream habitat	Ongoing, but all push up dams not expected to be corrected for at least 15 years. A comprehensive survey has not been completed	Immediate	High, if comply with fish passage design criteria
Remove or replace barriers blocking passage -- dams, road culverts and irrigation structures	USFS, BLM, watershed councils, SWCDs, ODOT	Ongoing	Access to upstream habitat	Ongoing, replacing all culverts blocking fish passage expected to take 20 years (see Appendix G)	Immediate	High, if comply with fish passage design criteria
Construct ladders over existing permanent concrete or earth fill dams	ODFW, SWCDs	Ongoing	Provide access to upstream habitat	Ongoing, providing passage at all diversion and pond barriers will take many years	Immediate	High if comply with fish passage design criteria
Provide screening at 100% of irrigation diversions	ODFW, SWCDs	Ongoing	At point of diversion	Approximately 39 diversions need to be screened	Immediate	High if comply with fish passage design criteria
Replace screens that do not meet criteria	ODFW	Ongoing	At point of diversion	Approximately 47 screens need to be replaced, should take many years	Immediate	High if comply with fish passage design criteria

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
Soil and Water Conservation Districts	Irrigation dam improvements, culvert replacement or retrofits	Private lands on John Day R and steelhead bearing tributaries above Dayville		The Grant Soil and Water District is constrained by the construction window of opportunity.
ODFW	Fish Passage/Screening	Private lands on John Day R and steelhead bearing tributaries above Dayville	No	The program completes a minimum of one project per year, but is dependent upon landowner cooperation and limited funding
USFS, BLM	Culvert replacement	Federal lands on Canyon Creek, Little Pine have been recently emphasized, others may be identified	Uncertain	See USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below. The BLM has no adult barriers at culverts. Monitoring is needed to determine if upstream passage for juveniles is an issue.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.				
Watershed Councils	Road Crossing Passage improvements, passage improvements	Private lands on John Day R and steelhead bearing tributaries above Dayville	No	Yes
ODOT	Culvert replacement or retrofit	Pine and Beech creeks, others may be identified		See State of Oregon programmatic review -- Appendix F.
BOR	John Day Basin Program	As identified by SWCD, ODFW, and others	Yes	No
CTWSRO	John Day Basin Program	Private lands on John Day R and steelhead bearing tributaries above Dayville in cooperation with SWCD	No	Yes, the tribe contracts with Soil and Water Districts to assist with consultation, permits, and monitoring

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Most of the mainstem passage problems have been addressed, but there are many tributaries where adult passage is blocked and more areas where juvenile passage problems occur. Irrigation dams, stock ponds, and road culverts are the primary causes of passage issues. In the Upper John Day subbasin, the Grant SWCD has implemented many passage improvement projects and currently has a waiting list of landowners who want them to correct passage problems at irrigation diversions on tributaries as well as the few remaining mainstem problem areas. The Grant SWCD is currently constrained by a relatively short in-water work period (4-6 weeks), so it will likely take another 10 years to address most of the tributary passage problems. Other Soil and Water Districts are also correcting passage at irrigation diversions and improperly installed culverts, but are constrained by funding and by personnel needed for construction oversight. An inventory of road crossings on state and county roads in 1999 indicated 14 culverts on state owned roads and 43 culverts on county owned roads within the Upper Mainstem John Day population boundaries did not meet fish passage criteria. Appendix G presents an inventory of culverts with known passage problems on state or county owned roads. Some of those culverts have been replaced with structures that do meet the fish passage criteria, but much work remains. Watershed councils and ODOT, who are the principal entities working on culverts are constrained primarily by funding. An inventory of road crossings on federal lands indicates juvenile passage problems are pervasive, particularly on National Forests, with approximately 54 culverts not meeting passage criteria in this population. The US Forest Service and BLM are constrained primarily by funding and the personnel needed for NEPA analysis. At the current rate of culvert replacements it will take over 50 years to correct all passage problems on National Forests, however, the Forest Service Pacific Northwest Region's Aquatic Restoration Strategy (USDA-FS, 2005) provides guidance that will help prioritize culvert replacements for this population. The BLM has no adult barriers at culverts. Monitoring is needed to determine if upstream passage for juveniles is an issue.Another constraint is that existing state laws do not require passage improvements at existing barriers unless there is a major change in the structure, such as reconstruction or significant modifications, so landowner cooperation is critical for improving passage throughout the subbasin.

See Strategy 2, Lower Mainstem John Day River population for further discussion.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Mainstem John Day River from Dayville to Blue Mt. Hot Springs (1)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	Primarily fry and 0+	Restoring channel migration processes will require a landowner willing to sacrifice irrigated pastureland. Opportunit ies may be limited to property owned by CTWSRO, above Prairie City.
Reconnect side channels and off-channel habitats to stream channels	Mainstem John Day River from Dayville to Blue Mt. Hot Springs (1), Canyon (1), Indian (2), and Pine (2) crs	Degraded floodplain, altered hydrology	Removal of side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity, spatial structure	Primarily fry and 0+	There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows.
Restore wet meadows	Canyon (2), EF Beech (2), Upper Belshaw (1)	Degraded floodplain, altered hydrology	Removal of wetlands	Abundance, productivity	Primarily fry and 0+	

Strategy 3. Maintain and restore floodplain connectivity and function.						
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	Canyon (1), Fields (1), Belshaw (2), Dixie (2), Strawberry (2)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat	Abundance, productivity, spatial structure	Primarily fry and 0+	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain to channel	ODFW, watershed council, SWCD, USFS, BLM	Ongoing	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High
Reconnect side channels and off-channel habitats to stream channels	ODFW, watershed council, SWCD, USFS, BLM, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, because of widespread need	5-15 years, depending upon frequency and duration of channel altering flows	Moderate, depends upon how extensive the project is and frequency and duration of channel altering flows
Restore wet meadows	TNC, USFS, CTWSRO	Ongoing and planned	Benefits of improved channel morphology localized, improved water table and resulting increased streamflow and lower water temperatures have high dispersal downstream	Long term	5-15 years	Moderate
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes	ODFW, CTWSRO, USFS, BLM	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Long term, due to acceptance by landowners and widespread need	Within 5 years once the dams are built	Moderate-high, dependent upon acceptance by landowners

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Private lands on John Day River and tributaries above Dayville	No	Active measures used only if specific needs cannot be addressed by passive restoration techniques, program limited by funding.
USFS, BLM	Stream enhancement program	Federal lands on John Day River and tributaries above Dayville. Only when specifically identified that passive restoration is not working.	Yes in some areas, no in others due to limited funding	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. May need expansion. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	Private lands on John Day River and tributaries above Dayville	Dependent upon need and funding	Active measures used only if specific needs cannot be addressed by passive restoration techniques, limited by funding.
Soil and Water Conservation Districts	Watershed restoration	Private lands on John Day River and tributaries above Dayville		See State of Oregon programmatic review -- Appendix F.

Strategy 3. Maintain and restore floodplain connectivity and function.				
Nature Conservancy and other NGOs	Restoration projects	None currently identified, but conservation easement exist on Dry and Widows creeks	Yes	No actions currently underway, should seek new opportunities.
CTWSRO	Watershed restoration	Forrest Ranch and private lands in cooperation with SWCD	Uncertain	Dependent on funding availability.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Bank stabilization using some rock is still infrequently occurring after high water events in the Upper John Day River, primarily along irrigated pastures. These bank stabilization projects have historically relied on riprap and large rock, however in recent years the high economic and ecological cost of bank armoring with riprap and of channelization has been recognized, so the emphasis has shifted toward a more passive approach for stabilization, primarily through riparian vegetation improvements. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Mainstem John Day River from Dayville to Blue Mt. Hot Springs (1), Indian (1), Pine (1), lower Beech (1), lower McClellan (2), lower Moon (2), lower Laycock (2), middle Canyon (1), lower Fields (2), lower Strawberry (1), lower Dixie (2), lower Isham (2), lower Dans (2) crs	Degraded channel structure and complexity, habitat diversity, riparian area degradation, connectivity with floodplain, sediment routing, water temperature, flows	Stream channelization, bank armoring, large wood removal, beaver removal, removal of riparian vegetation, livestock overgrazing in riparian areas	Abundance, productivity	Primarily fry and 0+	Restoring channel migration processes will require a landowner willing to sacrifice irrigated pastureland. Opportunit ies may be limited to property owned by CTWSRO, above Prairie City.
Place stable wood and other large organic debris in streambeds	Mainstem John Day River from Dayville to Blue Mt. Hot Springs (2), Indian (1), Pine (1), lower Beech (1), lower McClellan (2), lower Moon (2), lower Laycock (2), middle Canyon (1), lower Fields (2), lower Strawberry (1), lower Dixie (2), lower Isham (2), lower Dans (2), crs	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Large wood removal channelization	Abundance, productivity	Primarily fry and 0+	More active restoration techniques, such as rootwad placement or channel reconfiguration, may be appropriate in these reaches. Typical structures include rootwads, boulder clusters, whole trees, and rock weirs where appropriate.
Stabilize streambanks	Mainstem John Day River from Dayville to Blue Mt. Hot Springs (1), lower Beech (2), lower Indian (2),	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, berming, bank armoring, overgrazing in riparian areas	Abundance, productivity	Primarily eggs, fry and 0+	Some bank erosion is inevitable and beneficial. However, where erosion is actively taking place due to unnatural processes, stabilization may be needed to reduce fine sediments.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, USFS, BLM, watershed councils	Ongoing and planned	For the treated stream reach	Short term, once identified	Physical response will be immediate, biological response may take 5-10 years	High

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Place stable wood and other large organic debris in streambeds	ODFW, USFS, watershed councils, BLM, SWCDs	As needed	For the immediate stream reach	Once identified, short term	Immediate	High
Stabilize streambanks	ODFW, USFS, watershed councils, BLM, SWCDs	Ongoing	For the treated stream reach, physical benefits dispersed downstream	Passive stabilization techniques are preferred and take longer to implement	With passive restoration the response may take 15 years	Medium to high, depending upon the extent of the treatments

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Private lands on John Day River and tributaries, once identified as deficient	No	Active measures used only if specific needs cannot be addressed by passive restoration techniques, program limited by funding.
USFS, BLM	Stream enhancement program	Federal lands on John Day River and tributaries, once identified as deficient. Only when specifically identified that passive restoration is not working.	Yes in some areas, no in others	The USFS preferred strategy is passive restoration; managing riparian areas to protect channel-forming processes. PACFISH BMPs are generally sufficient for passive restoration but active restoration funds are limited. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
Watershed Councils	Watershed restoration	Population-wide	Uncertain	Limited resources.
Soil and Water Conservation Districts	Watershed restoration	Private lands on John Day River and tributaries, once identified as deficient		Active management, only if specific needs cannot be addressed by passive restoration techniques.
CTWSRO	Watershed restoration	Private lands on John Day River and tributaries, once identified as deficient in cooperation with SWCD	Uncertain	
NGOs	Watershed restoration	None currently identified	Uncertain	No actions currently planned.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Instream activities have not been identified as a high priority by the recovery planning team or the subbasin plan team except when identified as a need for specific sites. The planning team prefers that more passive approaches, such as riparian and upland improvements be emphasized. Typically, instream activities that would improve floodplain function and channel migration processes would include placement of rootwads, whole trees, or boulder clusters to improved habitat complexity and habitat diversity where those parameters are deficient and not expected to improve with passive restoration. Another structural activity would be to construct boulder or log weirs to raise the water table, but only where a passive approach has not worked.

The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategic Actions and Impacts on Limiting Factors, Threats, and Population

Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	Some reaches of the upper mainstem John Day River (1) and Ingle (2), Harper (2), Beech (1), Bear (1), Birch (2), Dans (2), and Reynolds (2) crs; the lower reaches of Fields (1), Belshaw (1), Cummings (2), Moon (2), Riley (1), Strawberry (2), Pine (2), and Laycock (2) crs	Degraded riparian area, channel structure and complexity, floodplain degradation, altered hydrology, sediment, water quality	Overgrazing of riparian area, channelization, stream bank armoring, tree harvest in riparian areas, changes in plant communities (including invasive plants), loss of beaver dams	Abundance, productivity	Primarily fry and 0+	Primary methods of riparian enhancement include riparian corridor fences to exclude livestock, changes in grazing management that promote riparian recovery, and planting of native shrubs.
Develop grazing strategies that promote riparian recovery	Some reaches of the upper mainstem John Day River (1) and Ingle (2), Harper (2), Beech (1), Bear (1), Birch (2), Dans (2), and Reynolds (2) crs; the lower reaches of Fields (1), Belshaw (1), Cummings (2), Moon (2), Riley (1), Strawberry (2), Pine (2), and Laycock (2) crs	Same as above	Livestock overgrazing of riparian area	Abundance, productivity	Primarily fry and 0+	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities	ODFW, Watershed Councils, SWCDs, USFS, BLM, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, (see above)	High, based on experience with existing grazing management and riparian recovery projects
Develop grazing strategies that promote riparian recovery	NRCS, AFS, USFS, BLM, SWCDs, ODFW, Watershed Councils, CTUIR	Ongoing	Riparian function will be limited to specific reach; water quality benefits will have high dispersal downstream from site	Long term because of widespread need	5-15 years, depending upon grazing plan adopted. Riparian corridor fencing and removal of riparian grazing has the fastest recovery rate.	High, based on experience with existing grazing management and riparian recovery projects

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Private lands on John Day River and tributaries above Dayville	No	Limited by funds.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.				
SWCDs	Upland improvements, riparian improvements	Private lands on John Day River and tributaries above Dayville		
USFS and BLM	Upland improvements, riparian improvements	Federal lands on John Day River and tributaries above Dayville	Uncertain	PACFISH BMPs are generally sufficient for passive restoration, but active restoration funds are limited. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
NRCS	Upland improvements, riparian improvements	Private lands on John Day River and tributaries above Dayville	Yes	Program sufficient.
ODA	Agricultural Water Quality Management Programs	Private lands on John Day River and tributaries above Dayville		See State of Oregon programmatic review -- Appendix F.
CTUIR	Watershed restoration	Forrest Ranch property and private lands on John Day River and tributaries above Dayville in cooperation with SWCD	Uncertain	Program approach sufficient. Scope could be increased.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Overgrazing of riparian areas by livestock continues, however it is not as widespread as historically. Interest by private landowners and public land managers in riparian improvement remains high. See Strategy 5, Lower Mainstem John Day River population for further discussion. Implementation of PACFISH standards and guides for most Forest and BLM programs has been highly successful over most of this population's area, but implementation of PACFISH Standards and Guides for FS grazing management program remains challenging in some locations. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.				

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement agricultural water conservation measures	Fields (1), Indian (1), McClellan (2), Pine (1), Beech (1), Bear (2), Strawberry (1), Isham (2), Dean (2), Moon (2), Laycock (1), Dog (2), Ingle (2), and Riley (2)crs; John Day River, Dayville to Mt. Vernon (1)	Altered hydrology, low flows, high temperatures	water withdrawals, land conversion on uplands, road network	Abundance, productivity	Primarily, fry and 0+	Fields, Indian, McClellan, Pine, Beech, Bear, Strawberry, Isham, Dean, Moon, Laycock, Dog, Ingle, and Riley crs (all Upper John Day) have significantly less than naturally available flow or are either dry or intermittent in their lower reaches due to irrigation withdrawals. During low water years, the mainstem John Day River from Dayville to Mt. Vernon is intermittent.
Improve irrigation conveyance and efficiency	Fields (1), Indian (1), McClellan (2), Pine (1), Beech (1), Bear (2), Strawberry (1), Isham (2), Dean (2), Moon (2), Laycock (1), Dog (2), Ingle (2), and Riley (2)crs; John Day River, Dayville to Mt. Vernon (1)	Low flows, high temperatures	Water withdrawals, loss during conveyance	Abundance, productivity	Primarily, fry and 0+	

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Increase pool habitat (beaver ponds)	Fields (2), Indian (1), McClellan (2), Pine (1), Beech (1), Bear (1), Strawberry (2), Isham (2), Dean (2), Moon (2), Laycock (1), Dog (2), Ingle (2), and Riley (1)crs				Primarily, fry and 0+	
Floodplain aquifer recharge		Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily, fry and 0+	
Lease or acquire water rights and convert to instream	Fields (1), Indian (1), McClellan (2), Pine (1), Beech (1), Bear (2), Strawberry (1), Isham (2), Dean (2), Moon (2), Laycock (2), Dog (2), Ingle (2), and Riley (2)crs; John Day River, Dayville to Mt. Vernon (1)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily, fry and 0+	The Upper John Day River does not meet requested in stream water right flows for all of August and the first half of September during irrigation season. Some tributaries are dry where they join the John Day River.
Monitor/regulate water withdrawals	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Primarily, fry and 0+	
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement agricultural water conservation measures	SWCD, watershed councils, NRCS	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights
Improve irrigation conveyance and efficiency	SWCD, OWEB, watershed councils, NRCS, landowners	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and dependent upon landowner willingness to participate and availability of projects	Immediate	High, if the saved water is protected from being appropriated to a downstream user in areas with instream water rights
Increase pool habitat (beaver ponds)	SWCD, ODFW, CTWSRO, USFS	Ongoing	High dispersal downstream	Unknown	Immediate increase in instream flow	High
Floodplain aquifer recharge	CTWSRO, SWCDs	Planned, some ongoing	Potentially high dispersal from recharge project site downstream for many miles	Long term, although opportunities for pilot projects is dependent upon willing landowner	Immediate	High, if the additional water is protected from being appropriated to a downstream user in areas with instream water rights
Lease or acquire water rights and convert to instream	OWRD, FSA, OWEB, Oregon Water Trust, others	Ongoing	Point of diversion downstream to mouth of John Day River	Long term and highly dependent upon landowner willingness to lease.	Immediate	High, if the leased water is protected from being appropriated to a downstream user in areas with instream

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
						water rights. FSA pays higher rates for CREP enrollment when water rights are leased for instream use.
Monitor/regulate water withdrawals	OWRD	Ongoing	Point of diversion downstream to mouth of John Day River	Long term, dependent upon OWRD enforcing the requirement to measure water usage	Immediate	High if water user reporting requirement and installation of measuring devices on diversions is implemented
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program, riparian improvements	Private lands on John Day River and tributaries above Dayville	No	Limited in scope.
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Private lands on John Day River and tributaries above Dayville where irrigation withdrawals occur	Uncertain	See State of Oregon programmatic review–-Appendix F.
Oregon Water Trust and BOR	Leasing and Purchase of Water Rights	John Day River and above John Day and tributaries above Dayville. Leases currently exist on Dixie Creek and John Day River above Mt Vernon.	No	Sufficient where applied, program could expand with additional funding.
Soil and Water Conservation Districts	Improve irrigation efficiency, upland improvements, riparian improvements	Private lands on John Day River and tributaries above Dayville		See State of Oregon programmatic review – Appendix F.
NRCS	Upland improvements, riparian improvements	Private lands on John Day River and tributaries above Dayville	No	Limited in scope.
CTWSRO	Watershed restoration program	Forrest Ranch property and private lands on John Day River and tributaries above Dayville in cooperation with SWCD	Uncertain	Approach sufficient, scope is limited.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
Many landowners have converted from flood to sprinkler or gated pipe irrigation that makes more efficient use of the water and grows more palatable forage, but there has not been an effective mechanism to protect saved water from being used by another irrigator downstream. Water measuring devices are just beginning to be required on irrigation withdrawals and while progress is being made there is considerable resistance from irrigators, particularly in the Upper John Day. Flows are also improving because of projects that restore historical cover types by removing juniper, reintroducing fire, enrollment into CRP, and control of invasive/noxious plants. Primary constraints on implementing additional projects are funding, instream water rights that are junior to most irrigation rights, and water laws that sometimes conflict with conservation practices.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.
Approximately 120 miles of stream in the Upper Mainstem are protected with either existing or pending instream water rights. The instream water rights do not preclude further appropriation of water until flows in the affected reach drop down to the instream water rights as adopted by OWRD. US Bureau of Reclamation, as required in the Columbia River Biological Opinion, is required to identify and assist with passage improvement design and flow restoration. They have partnered with Oregon Water Trust on several water leases, most notably in Standard Creek, tributary to Dixie Creek.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Increase riparian shading	Mainstem John Day River (1), Beech (1), EF Beech (2), Canyon (1), Grub (2), Indian (1), Pine (1), Laycock (2), Belshaw (1), Fields (1), Strawberry (2), lower Dans (2), Riley (1), Ingle (1), Harper (1), and Bear (2) crs	High water temperatures	Degraded riparian forests	Abundance, productivity	Primarily fry, juveniles	Elevated water temperature is the most pervasive water quality problem for the Upper John Day River population, with 27 stream reaches listed as water quality limited. Additional reaches would probably be listed if water temperature data were available.
Manage return flow to reduce extreme stream temperatures	Mainstem John Day River, from South Fork to Blue Mt Hot Springs (1).	High water temperatures	Water withdrawals	Abundance, productivity	Primarily fry, juveniles	Many projects that improve water quality by reducing irrigation return water have been completed, particularly between the town of John Day and the National Forest Boundary above Blue Mt. Hot Springs.
Reduce chemical pollution and nutrient inputs	Mainstem John Day River from the South Fork to Blue Mt Hot Springs (1).	Chemical pollution	Pesticides, fertilizers, herbicides, vehicle hydrocarbons, etc.	Abundance, productivity	Primarily fry, juveniles	Using more efficient irrigation methods, which reduces the amount of surface water returning to the stream, should result in fewer nutrients from pastures reaching the John Day River. Reducing nutrient loads will contribute to increased water quality by reducing biological oxygen demand and algae blooms.
Apply BMPs to animal feeding operations	John Day River between the South Fork and Blue Mt. Hot Springs (1)	Degraded water quality	Animal feed operations	Abundance, productivity	Primarily fry, juveniles	There are very few feedlots, but significant use of riverside meadows for winter feeding operations.
Continue TMDL monitoring	Temperature: Mainstem John Day River (1), Beech (1), EF Beech (2), Canyon (2), Grub (2), Indian (1), Laycock (1), Belshaw (2), Fields (2), and Bear (2) crs Sediment: Indian Cr (from burned area) (1)	Degraded water quality, sediment routing	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	Primarily fry, juveniles	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Increase riparian shading	ODFW, Watershed Councils,	Ongoing	Water quality benefits will have	Long term because of widespread	5-15 years	High

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
	SWCDs, USFS, BLM, CTUIR		high dispersal downstream from site	need		
Manage return flow to reduce extreme stream temperatures	SWCDs, watershed councils	Ongoing	Water quality improvement would have high dispersal downstream	Less than 5 years, once the project has been identified	Immediate	High, reduced temperatures has been well documented
Reduce chemical pollution and nutrient inputs	ODEQ, others	Ongoing		Ongoing	Reduce chemical pollution immediately	High
Apply BMPs to animal feeding operations	ODA	Ongoing	Water quality improvement would have high dispersal downstream	Some treatments could be done immediately. There are few animal feeding operations within the subbasin, only one of which has been identified as a problem	5-15 years	High, once a treatment has been agreed upon
Continue TMDL monitoring	USFS, ODFW, SWCD, ODEQ	Ongoing	Basinwide	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA	CREP, CRP	Resource need is widespread, but acceptance is lacking	No	Limited by acceptance of landowners.
ODEQ	Mine Waste Program	None currently identified, although extensive gold mining has occurred on John Day River near the town of John Day, on Canyon Creek and Dixie Creek		See State of Oregon programmatic review -- Appendix F.
ODA	Confined animal feeding operations (CAFO), Agricultural Water Quality Management Program	None currently identified		See State of Oregon programmatic review -- Appendix F.
ODEQ, ODA, SWCD, USFS	Sedimentation Monitoring (TMDL Development and Implementation)	John Day River and tributaries above Dayville		See State of Oregon programmatic review -- Appendix F. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Reducing water temperatures through the use of improved riparian vegetation and more efficient methods of irrigation may take several years to provide measurable results. Many projects that improve water quality by reducing irrigation return water have been completed. Opportunities for additional irrigation return water cooling projects exist above and below the town of John Day. Low streamflows during the hottest part of the year exacerbate the already warm water temperatures. Opportunities for increasing streamflow through leasing of water rights, which often results in cooler water over a longer stream reach, are being pursued by Oregon Water Trust and US Bureau of Reclamation. Constraints for future projects include acceptance by landowners and a secure, long term funding source.

The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	**Geographic Locations (1-first priority, 2-second priority)**	**Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Restore native upland plant communities	Bear (2), Grub (1), Beech (1), Belshaw (1), Cummings (1), Pine (2), Indian (2), Strawberry (2), and Laycock (2) crs	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices, loss of water storage capacity	Abundance, productivity	Primarily fry, juveniles	Upland improvements such as restoring native plant communities and controlling invasive weed species will improve precipitation infiltration rates and ultimately improve watershed health, including the hydrograph.
Upgrade or remove problem forest roads	Forest lands	Same as above	Road network	Abundance, productivity	Primarily fry, juveniles	
Initiate upland improvement demonstration projects	Bear (2), Grub (1), Beech (1), Belshaw (1), Cummings (1), Pine (2), Indian (2), Strawberry (2), and Laycock (2)crs	Same as above	Upland land use practices	Abundance, productivity	Primarily fry, juveniles	
Manage vegetation, including juniper removal	Bear (2), Grub (1), Beech (1), Belshaw (1), Cummings (1), Pine (2), Indian (2), Strawberry (2), and Laycock (2) crs	Altered hydrology, sediment routing	Invasive plants	Abundance, productivity	Primarily fry, juveniles	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Population-wide	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	Primarily fry, juveniles	

Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Restore native upland plant communities	SWCD, USFS, BLM	ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term		
Upgrade or remove problem forest roads	USFS, BLM, ODF, ODOT	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff. Decommissioning may take many years	5-15 years	Moderate, although funding on public lands and landowner cooperation on

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
						private lands will determine rate of treatment
Initiate upland improvement demonstration projects	ODFW, NOAA Fisheries, USFWS, USFS, BLM, CTWSRO, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed
Manage vegetation, including juniper removal	USFS, BLM, NRCS, SWCDs, Watershed Councils	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Juniper control can be done quickly, other strategies such as control of invasive plants may take more than 20 years	5-30 years	Moderate
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	SWCD, USFS, ODA, CTWSRO, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of Agricultural Water Quality Management Plans	0-20,years, depending upon treatments applied	Moderate, dependent upon voluntary landowner participation

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
NRCS/Farm Service Agency	CRP	Private lands on John Day River and tributaries above Dayville	No	Limited in scope.
SWCDs	Juniper control	Private lands on John Day River and tributaries above Dayville		Needs expansion.
ODFW	Green Forage	Private lands on John Day River and tributaries above Dayville	No	Very small program.
USFS/BLM	Forest Plan, PACFISH, Resource Management Plan	Federal lands on John Day River above Forest boundary, and tributaries on Malheur National Forest	Yes, but highly dependent upon funding and monitoring	Particularly monitoring needs expansion. See USFS/BLM Program Sufficiency Assessment -- Appendix E and USFS Region's Aquatic Restoration Strategy (USDA-FS, 2005). See discussion in Gaps commentary below.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
ODA	Agricultural Water Quality Management Program	Private lands on John Day River and tributaries above Dayville		See State of Oregon programmatic review -- Appendix F.
CTWSRO	Watershed Restoration	Forrest Ranch property and private lands on John Day River and tributaries above Dayville in cooperation with SWCD	Uncertain	Continued funding is uncertain.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
See discussion for Strategy 8, Lower Mainstem John Day River population. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed. Implementation of PACFISH standards and guides for Forest and BLM programs has been highly successful for passive upland restoration over most of this population's area. The limitations to all the programs are funding and, to a lesser extent, acceptance by landowners.

9.3.10 Habitat Strategies and Actions for Umatilla River Steelhead Population

Primary limiting factors: high water temperature, sediment routing, impaired fish passage, degraded channel structure and complexity and altered hydrology (low flow).

Primary threats: current land use practices that reduce habitat quality, quantity and disrupt ecosystem functions.

Table 9-2, behind the habitat strategy and action tables for the Umatilla, provides a cross reference of Geographic Areas and MaSAs/MiSAs. Table 8-35 identifies stream barriers to upstream steelhead passage in the Umatilla watershed.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition, conservation easements and cooperative agreements	North Fork Umatilla R (1); Umatilla R., Meacham Cr. to forks (1); Buck Creek (1); NF Meacham Cr. (1); E. Meacham Cr (1); Thomas Cr.(1); W. Birch Cr., Bear Cr. to headwaters (1); E. Birch Cr., California Gulch to headwaters (1); SF Umatilla R., mouth to Thomas Cr.(1); Umatilla R., Butter Cr. to Westland Dam and Stanfield Dam to McKay Cr.(2); Umatilla R., Three Mile Dam to Butter Cr. (2)	Loss of habitat quantity and diversity, channel stability, sediment, low flow and high temperatures	Cultivation, forestry, grazing, urban development	Abundance, productivity	All	Agreements (conservation easements, cooperative agreements, etc.) could be made with private landowners in areas where priority habitats exist to maintain the current habitat values. Agreements in areas with priority habitats may include: Putting in no-cultivation riparian buffers on agricultural lands that are currently cultivated up to the channel's edge, increasing riparian buffer widths associated with forested areas, protecting unstable areas, or changing other types of management in riparian areas.
Continue existing protections and/or increase protection of Federal lands; implement Forest Practices Act and PACFISH	North Fork Umatilla R (1); Umatilla R., Meacham Cr. to forks (1); Buck Creek (1); NF Meacham Creek (1); East Meacham Cr (1); Thomas Cr. (1); West Birch Cr., Bear Cr. to headwaters (1); E. Birch Cr., California Gulch to headwaters (1); SF Umatilla R., mouth to Thomas Cr. (1)	Same as above	Forestry, cultivation, grazing, urban development	Abundance, productivity	All	Current protections on USFS lands such as Riparian Habitat Conservation Areas should be continued and maintained. Protection on Federal lands may be increased through the NEPA process or ESA consultation. Aquatic habitat issues are addressed through both processes. Actions may include expanding riparian buffers, changing management within or near riparian areas, and identifying sensitive areas to avoid. All the options listed for added protection are directed through PACFISH program/management direction but would be considered "New" actions to be applied if/when the need is identified. Forest Plan management

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
						direction (landscape-scale) for roadless areas, wildlife management emphasis and Wilderness are unlikely to change significantly in the near future.
Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function	Umatilla R., Meacham Cr. to forks ; Thomas Creek (1); West Birch Cr., Bear Cr. to headwaters (1); Bear Creek (West Birch) and tribs (1); E. Birch Cr., mouth to headwaters (1); SF Umatilla R., mouth to Thomas Cr. (1); Umatilla R., Butter Cr. to Westland Dam and Stanfield Dam to McKay Cr (2); Umatilla R., Three Mile Dam to Butter Cr. (2); Birch Cr., mouth to forks (2); Umatilla R., Mission Br. To Meacham Cr. (1); Meacham Cr., mouth to North Fork (1); West Birch Cr., mouth to Bear Cr. (1); Buckaroo Cr (1); Meacham Cr., Sheep Cr. to headwaters (1)	Same as above	Same as above	Abundance, productivity	All	Setbacks could include: no-cultivation riparian buffers on agricultural lands that are currently cultivated up to the channel's edge, increasing riparian buffer widths associated with forested areas, protecting unstable areas, or changing other types of management in riparian areas.
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	Subbasin-wide	Same as above	Same as above	Abundance, productivity	All	To prevent degradation of existing habitat, Best management Practices and existing laws that protect aquatic habitat should be applied across the subbasin with emphasis on areas of very high quality.
Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues	Subbasin-wide	Same as above	Urban development	Abundance, productivity	All	Enforce existing land use laws that affect aquatic habitat and update laws that do not provide adequate protection.
Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance	Umatilla R., Meacham Cr. to forks (1); W. Birch Cr., Bear Cr. to headwaters (1); Bear Creek (West Birch) and tribs (1); E. Birch Cr., mouth to headwaters (1); Umatilla R., Butter Cr. to Westland Dam and Stanfield Dam to McKay Cr. (1); Umatilla R., Three Mile Dam to Butter Cr. (1); Birch Cr., mouth to forks (1); Umatilla R., Mission Br. To Meacham Cr. (1); Meacham Cr., mouth to North Fork (1); West Birch Cr., mouth to Bear Cr. (1); Iskuulpa Cr., Bachelor Cyn to headwaters(1); Buckaroo C (1); Meacham Cr., Sheep Cr. to headwaters(1)	Same as above	Urban development	Abundance, productivity	Abundance, productivity	Incorporating MCR steelhead priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance would allow the priority habitat areas to be protected while providing an expedient process for reviewing land uses.
Explore opportunities to incorporate priority areas into state legislation	NF Umatilla R (1); Umatilla R., Meacham Cr. to forks (1); Buck Creek (1); NF Meacham Cr (1); East Meacham Cr (1); Thomas Cr (1); West Birch Cr., Bear Cr.	Same as above	Rural and urban development	Abundance, productivity	All	Look for opportunities to make amendments that would incorporate increased protection for priority habitat areas.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
	to headwaters (1); E. Birch Cr., California Gulch to headwaters (1); SF Umatilla R., mouth to Thomas Cr. (1); Umatilla R., Butter Cr. to Westland Dam and Stanfield Dam to McKay Cr. (1); Umatilla R., Three Mile Dam to Butter Cr. (1)					
Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect high quality habitats through acquisition, conservation easements and cooperative agreements	CTUIR, ODFW, UBWC, TNC, RMEF, SWCDs	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5 years to decades with passive restoration approaches	High, based on previous cooperative agreements
Continue existing protections and/or increase protection of Federal lands; implement Forest Practices Act and PACFISH	USFS, ODF	Ongoing	Benefits accruing since 1995 for all streams in Umatilla subbasin on USFS lands, including priority GAs. Forest Practices Act applies to all commercial timber operations on private lands	Long term	Maintenance/improvement of existing conditions	High
Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function	CTUIR, ODFW, USFS, FSA, NRCS, SWCD	When need identified	Riparian areas associated with priority habitat areas	Long term	Immediate with continued improvement for up to 50 years. After 50 years habitat effectiveness will be maintained.	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	USFS, SWCDs, ODA, FSA, NRCS, CTUIR, ODSL, USACE	Ongoing	All priority areas within the Umatilla subbasin	Long Term	Maintenance of existing conditions	Moderate
Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues.	Municipalities	Unknown	Mid and lower subbasin; High dispersal downstream	Ongoing - unknown	Response is uncertain	It is unknown to what extent governments will address this need.
Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance	Umatilla County, CTUIR, ODFW	When possible	All priority areas within the Umatilla subbasin	Short term	Immediate with continued improvement for up to 50 years. After 50 years habitat effectiveness will be maintained.	Moderate, depends on implementation and enforcement

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Explore opportunities to incorporate priority areas into state legislation.	ODFW, CTUIR	When funding is available and amendment is possible	All priority areas within the Umatilla subbasin	Long term	Immediate with continued improvement for up to 50 years. After 50 years habitat effectiveness will be maintained.	Low

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTUIR	CTUIR Umatilla River Basin Anadromous Fish Habitat Enhancement Projects – Riparian Function	Birch Creek, Meacham Creek, Umatilla River	No	Yes, there is still potential for more conservation easements.
ODFW	Umatilla River Subbasin Fish Habitat Improvement Program, Fish Management Program	Birch Creek, Meacham Creek, Umatilla River	No	Yes, there is still potential for more conservation easements.
USFS	North Fork Umatilla River Wilderness and other specific Forest Plan management area allocations	Meacham Creek, North and South Fork Umatilla River and tribs	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
USFS	Land Exchange Program	Meacham Creek, North and South Fork Umatilla River and tribs, Pearson Creek (East Birch Creek)	No	See discussion below.
USFS	PACFISH/Umatilla Forest Plan	Meacham Creek, North and South Fork Umatilla River and tribs, West Birch Creek, Pearson Creek and other East Birch Creek tribs	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
USFWS	Umatilla Wildlife Refuge	Umatilla Wildlife Refuge	Yes	
US Army Corps of Engineers	Section 404/401 water alteration permitting	Subbasin-wide	No	Compliance validation and enforcement is inadequate due to lack of resources
ODSL	Waterway alteration permitting	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODA, SWCD	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
FSA, NRCS, SWCD	CREP, CCRP, CSP, EQIP	Subbasin-wide	No	The potential coverage of these programs has not been realized in Umatilla County.
CTUIR	Iskuulpa Creek	Iskuulpa Creek	Yes	Program meeting objectives.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

CTUIR and ODFW conservation easement programs have been effective at protecting and improving riparian habitat condition in the Umatilla subbasin. There is potential for considerable expansion of these programs. Emphasis should be placed on priority habitat areas for establishing easements. These agreements are typically 10 or 15 years in duration. Continuation of management and derived benefits are uncertain once agreements expire.

The Umatilla National Forest should emphasize protecting priority areas during project planning and implementation. Ongoing management actions sufficiently protect high priority aquatic habitats. These existing protections should be continued. PACFISH/Forest Plan Programs per se are sufficiently protective for lands in current ownership and require changing management or increasing buffers only when need is identified site-specifically ("New" actions). Most of FS lands (Meacham watershed, SF and NF Umatilla R. are already essentially fully protected under Forest Plan by protective management direction,- Roadless and Wilderness and Wildlife Emphasis Management Areas that prohibit road building and forest practices except in rare circumstances; PACFISH protections apply to all such activities. Meacham and Umatilla watersheds (FS) are essentially unroaded and unharvested, majority of existing road system is located on ridgetops, very little in stream bottoms. When/if needs are identified, additional aquatic habitat could receive increased protective status and a "new action". Adding additional wilderness areas and wild and scenic river segments would require designation by Congress. Priority areas for habitat protection as listed above that reside within the Umatilla National Forest should be assessed as to whether administrative designations apply to the areas that will support protection of these areas over the long term.

While permit processes implemented by the US Army Corps of Engineers are thorough and actions authorized are protective of aquatic resources, the program lacks personnel resources to insure that terms and conditions of permitted actions are followed. In addition, the agency lacks resources to adequately monitor waterways for non-permitted actions or act upon non-permitted situations reported by other agencies or private parties. See State of Oregon programmatic review -- Appendix F for comments on ODSL.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.
The USFS land exchange program has the potential to bring existing private lands under federal ownership and PACFISH protections. However, this program is completely voluntary on the landowner's part and the landowner would acquire public land and could very likely lower standards of resource protection. The land exchange is, however, a tool that could be used under very controlled circumstances to see increased protection of important aquatic habitats. But the purpose of the program is focused on consolidating land holdings and not necessarily protection of habitat. The Umatilla and Walla Walla Agricultural Water Quality Management (AgWQM) Area Rules require that management on agricultural lands allow the establishment, growth and maintenance of riparian or stream-side vegetation, consistent with site capability, to promote habitat and protect water quality by filtering sediment, stabilizing streambanks, naturally storing water, and providing shade. The AgWQM program is outcome-based rather than prescriptive, therefore allows landowners the flexibility to achieve water quality goals using available equipment, technology and innovation. The rules for each Management Area provide the enforceable backstop to the voluntary initiatives. The SWCDs are the local management agencies that provide the outreach, education and technical assistance. ODA is responsible for complaint investigations and enforcement actions. Technical and financial assistance is available through state and federal programs to landowners for establishing adequate riparian areas. The CREP program agreements are for durations of 10 or 15 years. There is no guarantee that the benefits and management actions will be continued beyond the duration of the agreements.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	Per Table 8-35 Priority (1) Butter Creek system priority (2) See Appendix G that identifies 25 culverts in need of replacement	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure, diversity	Primarily adults and 0+juveniles	See Table 8-35 for list of known passage barriers. The most serious passage barriers on the mainstem of the Umatilla River have been addressed. The watershed with the greatest need for passage remediation is Birch Creek.
Construct ladders over existing permanent concrete or earth fill dams	Per Table 8-35 Priority (1) Butter Creek system priority (2)	Impaired fish passage	Dams	Abundance, productivity, spatial structure, diversity	Primarily adults and 0+juveniles	
Provide screening at 100% of irrigation diversions	Unscreened diversions within current steelhead distribution (1); Butter Creek system priority (2)	Impaired fish passage	Irrigation diversions	Abundance, productivity	All	There is only one gravity flow diversion known to not have inadequate screening in areas that are occupied by steelhead. However, it is not known to what extent pump diversion are adequately screened.
Replace screens that do not meet criteria	Diversions within current steelhead distribution (1); Butter Creek system priority (2)	Impaired fish passage	Irrigation diversions	Abundance, productivity	All	
Operate and maintain fish passage facilities to meet criteria	Within current steelhead distribution (1); Butter Creek system priority (2)	Impaired fish passage and entrainment	Dams, culverts and irrigation diversions	Abundance, productivity, spatial structure, diversity	All	There are cooperative projects in place in the Umatilla subbasin to both physically maintain the facilities and provide biological oversight so they are operated to maintain optimum fish passage conditions.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove or replace barriers blocking passage such as	ODFW, CTUIR, SWCD, UBWC, USFS, ODOT, Umatilla County,	Ongoing	Access upstream of obstruction	Within 5 years	Immediate	High

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
dams, road culverts and irrigation structures	Municipalities, private landowners					
Construct ladders over existing permanent concrete or earth fill dams	ODFW, CTUIR, private landowners	Ongoing	Access upstream of obstruction	5-10 years	Immediate	High
Provide screening at 100% of irrigation diversions	ODFW, private landowners	Ongoing	Point of diversion	10-20 years	Immediate	High
Replace screens that do not meet criteria	ODFW, private landowners	Ongoing	Point of diversion	10-20 years	Immediate	High
Operate and Maintain fish passage facilities to meet criteria	CTUIR, ODFW, WID, private landowners	Ongoing	Facility site	Ongoing	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program, Fish Management Program	Subbasin-wide	No	More funding/implementation needed.
CTUIR	BPA Habitat Program	Subbasin-wide	No	More funding/implementation needed.
ODFW	Fish Screening Program	Subbasin-wide	Yes for gravity diversions	Need to inventory and address pump screening.
Westland Irrigation District	Fish facilities O and M	Lower Umatilla River	Yes	Program meeting objectives.
CTUIR/ODFW	Fish passage operations	Lower Umatilla River	Yes	Program meeting objectives.
USFS	Road Maintenance	Upper subbasin	No	More funding needed to address fish passage problems. Timeframe of implementation slow due to funding. See comments below.
SWCD, UBWC	Watershed Improvement	Subbasin-wide		See State of Oregon programmatic review – Appendix F.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

McKay, Butter and Willow creeks all historically supported summer steelhead, but steelhead are not currently present due to passage obstructions, inadequate screening and low flow problems. McKay Dam, constructed to store water for irrigation in the 1920's, completely blocks upstream passage of fish at RM 6 on McKay Creek. Unt il recent years, McKay Creek downstream of McKay Dam was completely de-watered when the reservoir was being filled. Butter Creek has a series of large diversion dams that block upstream passage throughout the subbasin. In addition, water withdrawal for irrigation is so severe that water flows out of the mouth for only a few days or weeks in any given year. Willow Creek Dam Was constructed in 1980 on Willow Creek just upstream of Heppner (RM 56) for flood control. Willow Creek Dam completely blocks upstream passage of fish. In addition, to Willow Creek Dam, numerous irrigation diversion dams throughout the Willow Creek watershed block passage. The lowest barrier in Willow Creek that blocks anadromous passage exists at RM 11. Steelhead are occasionally seen holding downstream of this dam. While the general condition of passage in these streams (McKay, Butter and Willow creeks) is understood, a thorough inventory and assessment is needed. This information can be used to pursue passage improvement for redband trout and to assess the feasibility of restoring passage for steelhead.

The USFS has identified passage barriers in addition to the ones listed in Table 8-35. The Forest Service's Aquatic Restoration Strategy for the Pacific Northwest Region (USDA-FS, 2005) helps prioritize restoration actions for this population, and helps deploy limited active restoration funding where it is most needed within the ESU.

Screening of gravity-feed irrigation diversions within currently occupied steelhead habitat is thought to be adequate, with the exception of the lower six miles of McKay Creek and one site in the Birch Creek drainage that is known to not meet criteria. There is now documented use of steelhead juveniles in lower McKay Creek, but no efforts have been made in the past or present to screen water diversions there. It is not known to what extent pump-feed irrigation diversions are adequately screened. There is a critical need to inventory and screen all pump-feed irrigation diversions within currently occupied steelhead habitat. A comprehensive inventory of water diversions and screening needs has never been done in the Umatilla subbasin. Thus, while it is not likely that there are gravity feed diversions that are not screened, there exists the possibility, lacking a thorough assessment of the situation. A comprehensive inventory of all water diversions should be done and inspection of these diversions to ensure adequate screening.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Umatilla R., Mission Br. to forks (1); Meacham Cr., mouth to North Fork (1); Birch Creek (1); West Birch, mouth to gorge (1); East Birch Creek mouth to Pearson Cr. (1)	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	All	Watershed scale problems and riparian management issues should be considered before active stream channel restoration is employed.
Reconnect side channels and off-channel habitats to stream channels	Umatilla R., Mission Br. to forks (1); Meacham Cr., mouth to North Fork (1); Birch Creek (1); West Birch, mouth to gorge (1); East Birch Creek mouth to Pearson Cr. (1)	Degraded floodplain, altered hydrology, habitat quantity and diversity	Removal of side channels, off-stream habitat	Abundance, productivity	All	Many streams in the subbasin are bordered by dikes and levies.
Remove dikes and levies	Umatilla R., Mission Br. to forks (1); Meacham Cr., mouth to North Fork (1)	Degraded channel structure and complexity	Stream channelization, bank armoring	Abundance, productivity	All	Many streams in the subbasin are bordered by dikes and levies.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplain habitats	ODFW, UBWC,, SWCD, USFS, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Short term, once identified	Physical response will be immediate for some, others will develop over years to decades	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Remove dikes and levies	CTUIR, UBWC, CDs	When opportunity identified	Within the stream reach and reaches downstream for temp and sediment	10+ years	Improved stream and floodplain functions - some benefits will be realized immediately and others will develop over years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Reconnect side channels and off-channel habitats to stream channels	ODFW, UBWC, SWCD, USFS, CTUIR	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Short term, once identified	Physical response will be immediate for some, others will develop over years to decades	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes

Strategy 3. Maintain and restore floodplain connectivity and function.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Birch Creek, Meacham Creek, Umatilla River	No	Additional implementation needed
CTUIR	BPA Habitat Program	Birch Creek, Meacham Creek, Umatilla River	No	Additional implementation needed
SWCD, UBWC	Watershed Restoration	Subbasin-wide		Involvement is currently limited. See State of Oregon programmatic review – Appendix F.
Watershed Council	Watershed Restoration	Subbasin-wide	No	There is a continuing need for landowner assistance to insure that issues are dealt with appropriately.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Intensive land uses within Umatilla subbasin flood plains and upslope habitats have led to dramatic changes in waterway characteristics since arrival of Euro-American pioneers to the area during the middle 1800's (Nagel 1997, unpublished; Beschta 1994). Channel alterations in the Umatilla subbasin have resulted in 1) straight, incised channels with minimal woody riparian vegetation, and 2) wide channels with increased dynamics and minimal woody riparian vegetation. There is a need for continued implementation of measures to address limiting factors.				

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Umatilla River, Mission Br. to forks (1); Meacham Creek, mouth to North Fork (1); Birch Creek (2); West Birch Creek (1), mouth to Gorge; East Birch Cr. (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature, flows	Stream channelization, bank armoring, large wood removal, loss of beaver dams, removal of riparian vegetation, livestock overgrazing in riparian areas	Abundance, productivity	All	Stream channel reconstruction and instream structures can be designed to correct channel stability problems. Where appropriate, passive treatments are preferred.
Place stable wood and other large organic debris in streambeds	Umatilla River, Mission Br. to forks (1); Meacham Creek, mouth to headwaters (1); North Fork Meacham Cr. (1); Birch Creek (1); West Birch Creek, mouth to Gorge (1); East Birch Creek (1); Bear Cr. (West Birch) (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Removal of large wood, beaver, trees in riparian areas; channelization and streambank armoring, livestock grazing	Abundance, productivity	Fry to adult	Aside from riparian vegetation, removal of large woody debris is one of the most pervasive habitat deficiencies in the Umatilla subbasin, either from direct removal or from removal of vegetation from riparian zones and floodplains. In areas where direct and immediate benefits to viability parameters can be addressed, large wood should be placed to improve overall ecosystem function. In areas where the lack of large wood is in addition to other habitat deficiencies such as flow and water quality, then restoration should focus on these over riding factors first.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Stabilize and protect streambanks	Umatilla River, Mission Br. to forks (1); Birch Creek (1); W. Birch Creek, mouth to Gorge (1); East Birch Cr. (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, bank armoring, livestock grazing in riparian areas	Abundance, productivity	Eggs, fry and adults	Stream that have been altered by human activities such as grazing, removal of riparian vegetation, Channelization and bank armoring often have vertical and/or lateral erosion rates elevated above natural conditions, as well as coarse substrates that are not suitable for spawning.
Construct rock and log weirs to create pool habitats or elevate incised channels	Umatilla River, Mission Br. to forks (1); Meacham Cr, mouth to North Fork (1); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Creek (1); Bear Cr. (West Birch) (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Large wood removal, trees in riparian area	Abundance, productivity	Fry to adult	Pools should be constructed strategically where other alternatives are not likely to accomplish this need, or constraints will not allow natural processes to form them. Artificial enhancement of pools should only be performed in areas where other parameters, such as water quality, would allow immediate use/benefits to be realized.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, CTUIR, UBWC	Ongoing; some needs identified in ODFW/CTUIR five-year action plan	Within the stream reach and reaches downstream for temp and sediment	25 years	Improved riparian vegetation and associated attributes and improved stream and floodplain structure and function – response time immediate to 10 years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Place stable wood and other large organic debris in streambeds	ODFW, UBWC, CTUIR, SWCDs	Ongoing as needed	Reach affected	Short term	Improved instream channel habitat diversity - some benefits will be realized immediately and others will develop in 1-5 years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Stabilize and protect streambanks	ODFW, CTUIR, SWCD, UBWC, private landowners	Ongoing; when specific opportunity identified	Within the stream reach and reaches downstream for temp and sediment	10+ years	Improved water quality – response time 1-5 years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Construct rock and log weirs to create pool habitats or elevate incised channels	ODFW, CTUIR	Ongoing; current action planned for Meacham Cr.	Treatment site	25 years	Increased quantity of pool habitat and channel and floodplain function – response time immediate to 5 years	High over short term, however structures often require maintenance
Remove dikes and levies	ODFW, CTUIR, SWCD, UBWC	When specific opportunities identified	Within the stream reach and reaches downstream for temp and sediment	Once specific action planned, short term	Some benefits will be realized immediately and others will develop over years to decades	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODFW	BPA Habitat Program	Birch Creek, Meacham Creek, Umatilla River	No	Additional implementation needed
CTUIR	BPA Habitat Program	Birch Creek, Meacham Creek, Umatilla River	No	Additional implementation needed
SWCD	Watershed Restoration	Subbasin-wide		See State of Oregon programmatic review – Appendix F.
Watershed Council	Watershed Restoration	Subbasin-wide	No	There is a continuing need for landowner assistance to insure that issues are dealt with appropriately.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Intensive land uses within Umatilla subbasin flood plains and upslope habitats have led to dramatic changes in waterway characteristics since arrival of Euro-American pioneers to the area during the middle 1800's (Nagel 1997, unpublished; Beschta 1994). Channel alterations in the Umatilla subbasin have resulted in 1) straight, incised channels with minimal woody riparian vegetation, and 2) wide channels with increased dynamics and minimal woody riparian vegetation. There is a need for continued implementation of measures to address limiting factors.				

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	Umatilla River, Mission Br. to forks (1); Meacham Creek, mouth to headwaters (1); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Cr (1); Bear Cr. (West Birch) (1); Iskuulpa Cr. (1)	Degraded riparian area, channel stability, floodplain degradation, sediment, water temperature	Livestock grazing, channelization, stream bank armoring, cutting of trees in riparian areas, changes in plant communities (including invasive plants), loss of beaver dams	Abundance, productivity, diversity	All	Historically, bank armoring with rock and channelization were used to stabilize stream banks at the detriment of riparian vegetation growth. In the last 15 years the high economic and ecological cost of bank armoring with riprap and of channelization has been recognized, so the emphasis has shifted toward a more passive approach for stabilization, primarily through riparian vegetation improvements.
Develop grazing strategies that promote riparian recovery	Umatilla River, Mission Br. to forks (1); Meacham Creek, mouth to headwaters (1); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Cr (1); Bear Cr. (West Birch) (1); Iskuulpa Cr. (1)	Degraded riparian area, channel stability	Livestock overgrazing of riparian area	Abundance, productivity, diversity	All	Grazing strategies, other than exclusion, should be developed to achieve riparian recovery in the next 10-15 years. Permanent or temporary exclusion of livestock from riparian areas remains the surest way to achieve riparian restoration where livestock have been the primary impact.
Develop no-cultivation riparian buffer on agricultural lands and establish riparian setbacks for structures in	Umatilla River, Mission Br. to Meacham (1); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Cr (1); Bear Cr. (West Birch) (1)	Degraded riparian area, channel stability, floodplain degradation, sediment, water	Degradation of riparian areas and function; residential	Abundance, productivity, diversity	All	In areas where development is occurring, that development should be adequately set back from streams so as not to interrupt natural stream processes.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
areas where activities could upset riparian function		temperature	development and cultivation			
Maintain existing widths of RHCAs on USFS lands	Umatilla R. and tribs, Meacham Cr. to Forks (1); South Fork Umatilla and tribs (1); Buck Cr. and tribs (1); Thomas Cr. and tribs (1); North Fork Meacham and tribs (1); East Meacham and tribs (1); Butcher Creek and tribs (1)	Degraded riparian area, channel stability, floodplain degradation	cutting of trees in riparian areas, changes in plant communities	Abundance, productivity, diversity	All	
Riparian exclosure fencing	Umatilla River, Mission Br. to forks (1); Meacham Creek, mouth to headwaters (1); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Cr (1); Bear Cr. (West Birch) (1)	Degraded riparian area, channel stability	Livestock grazing	Abundance, productivity, diversity	All	Excluding livestock from riparian areas remains the most effective tool of mitigating livestock impacts.
Close, remove, and restore riparian road prisms	Umatilla River, Mission Br. to forks (1); Meacham Creek, mouth to headwaters (1); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Cr (1); Bear Cr. (West Birch) (1)	Degraded riparian area, channel stability, sediment	Roads	Abundance, productivity, diversity	All	In many areas of the Umatilla subbasin, riparian roads have reduced riparian vegetation, confined stream channels, and continue to deliver fine sediment to channels. Regular road maintenance, or road relocation or elimination will restore allow natural riparian processes.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities including vegetative planting	ODFW, CTUIR, NRCS/FSA , UBWC, SWCD, ODA, private landowners	Ongoing	High dispersal downstream from site	25 years	Improved riparian vegetation and associated attributes – response time 5 years to decades	Moderate – plant survival varies based on techniques used
Develop/implement grazing strategies that promote riparian recovery	ODA, NRCS, FSA, USFS, private landowners	Ongoing	High dispersal downstream from site	Long term	Improved riparian vegetation and associated attributes – response time 5 years to decades	Depends on diligence of management applications
Develop no-cultivation riparian buffer on agricultural in areas where activities could upset riparian function	CTUIR, landowners, FSA/NRCS, ODFW	Ongoing	Cultivated land in close proximity to priority habitat areas within the Umatilla subbasin	Long term	Immediate with continued improvement for up to 50 years or until easement ends and management changes. After 50 years habitat effectiveness will be maintained	High
Maintain existing widths of RHCAs on USFS land	USFS	Ongoing	Benefits accruing since 1995 for all streams in Umatilla subbasin on USFS lands, including priority GAs.	Long Term	Maintenance/improvement of existing conditions	High
Riparian exclosure fencing	ODFW, CTUIR, NRCS/FSA, Watershed Council, SWCD, private landowners	Ongoing	High dispersal downstream from site	25 years	Improved riparian vegetation and associated attributes – response time 5 years to decades	High
Close, remove, and restore riparian road prisms	USFS, ODOT, Umatilla County, private landowners	Ongoing	Riparian areas within the subbasin where potential for riparian road closure and removal exists	Based on opportunity and need	Improved water quality – response time immediate with continued response for up to 50 years	High

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODA, SWCD	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
FSA, NRCS, SWCD	CREP, CCRP, CSP, EQIP	Subbasin-wide	No	The potential coverage of these programs has not been realized in Umatilla County
ODFW, CTUIR	BPA Habitat Program		No	Many additional miles of stream to be treated
USFS	Grazing management	Upper subbasin	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
USFS	Vegetation management	Upper subbasin	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODEQ	TMDL	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
Municipalities	Land use planning ordinances	Subbasin-wide	No	Needs expansion.
USFS	Road management	Upper subbasin		See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODOT	Road maintenance	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODF	Forest Practices Act, Road management	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
Umatilla County	Road maintenance	Subbasin-wide	No	Needs expansion to better address water and sediment routing to waterways.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
The Umatilla and Walla Walla AgWQM Area Rules require that management on agricultural lands allow the establishment, growth and maintenance of riparian or stream-side vegetation, consistent with site capability, to promote habitat and protect water quality by filtering sediment, stabilizing streambanks, naturally storing water, and providing shade. The AgWQM program is outcome-based rather than prescriptive, therefore allows landowners the flexibility to achieve water quality goals using available equipment, technology and innovation. The rules for each Management Area provide the enforceable backstop to the voluntary initiatives. The SWCDs are the local management agencies that provide the outreach, education and technical assistance. ODA is responsible for complaint investigations and enforcement actions. Technical and financial assistance is available through state and federal programs to landowners for establishing adequate riparian areas. The CREP program agreements are for durations of 10 or 15 years. There is no guarantee that the benefits and management actions will be continued beyond the duration of the agreements. Continued development adjacent to waterways is not suitable to the recovery of Mid. Columbia steelhead. Fish managers need to review the issue with Umatilla County and municipalities and identify ways to resolve problems with current regulations or their implementation.				

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Implement Umatilla Basin Project Phase I and II	Umatilla River from mouth to McKay Cr. (1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity	Parr to adult	Agricultural water diversions constructed on the lower Umatilla in the early 20th century lead to dewatering of the channel throughout the spring summer and fall. Implementation of the Umatilla Basin Water Exchange project has resulted in
Implement Umatilla Basin Project Phase III	Umatilla River from mouth to Thornhollow (1)	Flows, water temperatures, habitat	Water withdrawals	Abundance, productivity,	Parr to adult	

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
		quantity/diversity		diversity		restoration of flows in the mainstem of the Umatilla River so that migration and rearing of steelhead is better supported, but conditions are not fully restored. Continued implementation an maintenance of this project is critical for providing migration and rearing.
File for additional ISWRs	Butter Creek system (2); Bear Cr. (West Birch) (1); South Canyon Cr. (East Birch) (1); Westgate Canyon (East Birch) (1); East Fork Meacham Cr. (1); Twomile Cr. (2); Butcher Cr. (1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, spatial structure, diversity	Parr to adult	Most important spawning and rearing stream in currently utilized spawning and rearing habitat have instream water rights. However, no instream water rights exist in the Butter Cr. system
Implement agricultural water conservation measures	Butter Creek system (2); Umatilla River, Mission Br. to forks (2); Birch Creek (1); West Birch Creek, mouth to Gorge (1); East Birch Creek (1); Bear Cr. (West Birch)(1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity, spatial structure	All	The primary tributary streams where water withdrawals are affecting migration and rearing of steelhead include the Birch and Butter Creek watersheds. Dewatering and passage barriers are so severe in Butter Creek that steelhead are currently not documented to occur. B irch Creek continues to support steelhead, but water withdrawals are significantly impacting rearing and migration habitats.
Lease or acquire water rights and convert to instream	Butter Cr system (2); Umatilla River, Mission Br. to forks (2); Birch Cr (1); West Birch Cr, mouth to Gorge (1); East Birch Cr (1); Bear Cr. (W Birch) (1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity, spatial structure	Parr to adult	
Downstream water rights transfers	Umatilla River, Mission Br. to forks (2); Birch Creek (1); West Birch Creek, mouth to Gorge (1); East Birch Creek (1); Bear Cr. (West Birch) (1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity	Parr to adult	
Monitor/regulate water withdrawals	Subbasin-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Parr to adult	Many streams that historically flowed year long are now intermittent, creating fish passage barriers in the dewatered reach. Many of these due to water withdrawals
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Implement Umatilla Basin Project Phase I and II	BPA, BOR, OWRD, WEID, HID, SID, CTUIR, ODFW	Ongoing	From McKay Reservoir to mouth of the Umatilla River	Long Term	Improved water quality and flow – immediate response	High, but depends on continued BPA funding
Implement Umatilla Basin Project Phase III	BPA, BOR, OWRD, WEID, CTUIR, ODFW	In-planning	From McKay Reservoir to mouth of the Umatilla River	Long Term	Uncertain	Uncertain

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
File for additional ISWRs	ODFW	On hold	Specific to the stream reach	Unknown	Maintenance of existing conditions	High, depends on how resource managers implement protection
Implement agricultural water conservation measures	SWCDs	Ongoing	Depends on means used to protect instream flows	Short Term	Improved instream flow – response immediate	Moderate – depends on how saved water is protected, if any.
Lease or acquire water rights and convert to instream	OWRD., Oregon Water Trust, water right holders	Ongoing, when opportunities arise	From point of diversion downstream	Long term	Improved instream flow – response immediate	High, depending upon priority date of water right
Downstream water rights transfers	OWRD, private landowners	Ongoing	Reach between old and new point of diversion	Long Term	Improved instream flow – response immediate	High
Monitor/regulate water withdrawals	OWRD	Ongoing	From the point of diversion downstream to the mouth of the Umatilla River	Long term	Maintenance or improvement of existing conditions – response to regulation immediate	Moderate, staffing levels are inadequate
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
BOR/BPA	Umatilla Basin Project	Lower Umatilla River	No	Additional water is needed to meet target flows established for the basin project
OWRD	Streamflow Monitoring and Regulation, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust and BOR	Leasing and Purchase of Water Rights	Umatilla River, Birch Cr. system and Butter Cr. system	No	Additional implementation would help meet flow restoration needs
SWCD, ODFW, CTUIR, Watershed Council	Improve irrigation efficiency	Umatilla River, Birch Cr. system and Butter Cr. System	No	Additional implementation would help meet flow restoration needs
UBWC, SWCD, ODFW, CTUIR, NRCS	Upland improvements, riparian improvements	Subbasin-wide	Uncertain	Additional implementation would help meet flow restoration needs
Umatilla County	Noxious weed control	Subbasin-wide	Yes	
ODF	Forest Practices Act	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
USFS	Forest Management	Upper Subbasin	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)				
Phase I and II of the Umatilla Basin Project are currently meeting critical flow needs in the mainstem of the Umatilla River. This program should be continued to support migration and rearing of steelhead. Target flows				

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.
for the Umatilla River mainstem were established as part of the Basin Project to the life history needs of Chinook and coho salmon and steelhead. The Basin Project as currently implemented does not provide adequate water to meet the target flows throughout the times needed by these species, and fails to provide any flow mitigation for a significant length of the river in July and August. BOR, CTUIR and WID are currently seeking to expand the Basin Project (Phase III) to better meet flow needs for migration and rearing. As Phase III of the Basin project is developed, priority should be given to providing additional flow at the time and locations to meet the needs of MCR steelhead.
Significant efforts have been made in the lower Umatilla subbasin to use more efficient means of applying water to agricultural crops. There has been less emphasis on irrigation efficiency in other areas of the subbasin. Efforts should be taken to improve irrigation efficiency in areas such as the Birch Creek watershed where flow is a primary limiting factor. There are approximately 238 stream miles protected by instream water rights in the Umatilla subbasin. Voluntary flow restoration projects restored 14.9 cfs instream during 2006.
The Oregon Water Trust has put significant effort into gaining instream water leases in the Umatilla subbasin, with limited success. While it is unlikely that this approach could make a significant difference on the lower Umatilla River, tributary habitats could benefit substantially from water leasing. The Oregon Water Trust should maintain a "presence" in the subbasin to be in a position to capitalize on opportunities as they arise.
While instream water rights have been established on many of the important spawning and rearing stream in the subbasin, some have not. Where important spawning and rearing streams have not been protected by instream water rights, appropriate instream flow studies should be conducted and instream water rights applied for. In addition, consideration should be given to protecting and restoring flows in the Butter Creek drainage, where steelhead are currently extinct.
Projects to improve summer and fall streamflow and temperature by recharging shallow aquifers have been proposed, but none have been implemented to date. These types of projects are highly experimental in nature and should be accompanied by rigorous monitoring and evaluation to determine the net benefits of the action.
The primary tributaries in need of flow restoration actions are Birch and Butter creeks.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Address point sources of water pollution	Umatilla River (1); Birch Creek (1)	Chemical pollution	Sewage, Pesticides, fertilizers, herbicides	Abundance, productivity	Egg to Smolt	Point sources of water pollution are direct impacts that should be corrected through implementation of the TMDL and associated water quality management plan.
Implement water quality management plans	Subbasin-wide	Degraded water quality, flows, sediment routing, water quality	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	All	The Umatilla River water quality management plan addresses many water quality problems in the drainage.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Address point sources of water pollution	ODEQ, others	Ongoing	Specific point location	Ongoing	Reduce chemical pollution immediately	High
Implement water quality management plans	ODA, SWCD, Municipalities, Umatilla County, USFS, ODF, Irrigation Districts, private landowners, Industry, ODEQ	Ongoing	High dispersal downstream	Ongoing	Immediate	Moderate – degree of implementation is uncertain

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.				
Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA, NRCS, SWCD	CREP, CCRP, CRP, EQIP, CSP	Subbasin-wide	Uncertain	The potential coverage of these programs has not been realized in Umatilla County.
ODFW	BPA Habitat Program	Umatilla R. Birch Cr., Meacham Cr.	No	There is a need for additional buffers.
CTUIR	BPA Habitat Program	Umatilla R. Birch Cr., Meacham Cr.	No	There is a need for additional buffers.
ODEQ	TMDL, NPDES	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODF	Forest Practices Act	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
USFS	PACFISH	Upper Subbasin	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
SWCD	Landowner cost share programs for conservation farming practices	Subbasin-wide		More landowners could be included if funds were available. See State of Oregon programmatic review -- Appendix F.
Umatilla County	Noxious weed control	Subbasin-wide	Yes	Program sufficient.
US Army Corps of Engineers	Section 404/401 water alteration permitting	Subbasin-wide	No	Compliance validation and enforcement is inadequate due to lack of resources.
ODSL	Waterway alteration permitting	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODA, SWCD	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Although this threat is partially addressed by the Umatilla River Water Quality Management Areas Plan (WQMAP), the guidance provided to landowners on management of riparian areas is fairly general. There is also some uncertainty regarding the implementation of this plan's requirements, as enforcement is based on a complaint-driven system. There is a continuing need to establish more riparian buffers. Achievement of the TMDL targets is dependent of determination of system potential vegetation. During TMDL development, the best professional judgment of the team described the potential streamside shade-producing vegetation broadly, as continuous tree-belts on each side of the river.

The Umatilla and Walla Walla AgWQM Rules require control of sediment delivery to streams to acceptable levels, control of irrigation runoff, management of livestock grazing to prevent runoff of waste and sediment, and establishment and maintenance of riparian and streamside vegetation. Beginning in 2008, these land conditions will be enforceable by ODA. SWCD provides technical and financial assistance to private landowners.

The SWCD, in partnership from OSU Extension Service and NRCS, has been a leader in promoting adoption of high tech conservation farming practices. They have received grants to provide cost share for farmers to adopt direct seeding, variable rate fertilizer placement and selective weed control. This technology reduces tillage that results in less erosion and healthier soils, applies only the needed amount of fertilizer to crops and reduces the application of herbicides.

The CREP program agreements are for durations of 10 or 15 years. There is no guarantee that the benefits and management actions will be continued beyond the duration of the agreements.

While permit processes implemented by the US Army Corps of Engineers are thorough and actions authorized are protective of aquatic resources, this program lacks personnel resources to insure that terms and conditions of permitted actions are followed. In addition, the agency lacks resources to adequately monitor waterways for non-permitted actions or act upon non-permitted situations reported by other agencies or private parties. See State of Oregon programmatic review -- Appendix F for ODSL.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	**Geographic Locations (1-first priority, 2-second priority)**	**Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Restore native upland plant communities	Subbasin-wide	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices, loss of water storage capacity	Abundance, productivity	All	There are cooperative projects in place in the Umatilla subbasin.
Upgrade or remove problem forest roads	Subbasin-wide	Altered hydrology, sediment routing	Road network	Abundance, productivity	All	
Initiate upland improvement demonstration projects	Subbasin-wide	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	All	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Subbasin-wide	Altered hydrology, sediment routing	Upland land use practices	Abundance, productivity	All	

Action Implementation						
Actions	**Implementing Entity**		**Spatial Coverage**	**Implementation Timeframe**	**Expected Biophysical Response Timeframe**	**Certainty of Outcome**
Restore native upland plant communities	SWCD, USFS, NRCS, private landowners	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term	Decades	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Upgrade or remove problem forest roads	BLM, ODF, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff. Decommissioning may take many years	5-15 years	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Initiate upland improvement demonstration projects	ODFW, USFS, CTUUIR, Watershed Councils, SWCDs	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Employ BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	SWCD, USFS, ODA, CTUIR, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, dependent on implementation of water quality management plans and other plans	0-20,years, depending upon treatments applied	Moderate, dependent upon voluntary landowner participation

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
FSA, NRCS, SWCD	EQIP, CRP, CREP, CCRP	Subbasin-wide	Uncertain	The potential coverage of these programs has not been realized in Umatilla County.
USFS	Forest Management	Upper subbasin	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODFW/CTUIR	BPA Habitat Program	Umatilla R., Birch Cr., Meacham Cr.	No	Additional implementation is needed.
SWCD, Watershed Council	Watershed Restoration, OWEB	Subbasin-wide		Additional implementation is needed.
ODF	Private land protection from fire, Private Forest Program	Private and state forestlands throughout population		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
ODA, SWCD	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

The degree to which upland vegetation management issues are being addressed has not been summarized subbasin-wide so sufficiency is currently not well understood.

The AgWQM Area Plan addresses upland conditions, both on rangeland and cropland that must be met to prevent and control erosion and improve overall watershed health to achieve water quality goals. The Area Rules require control of soil erosion to acceptable levels, allowing riparian and stream-side vegetation to establish for bank stability, filtering and shade, and management of livestock to prevent runoff of sediment and animal wastes. SWCD and NRCS programs are providing incentives to landowners to adopt farming practices that are more environmentally protective.

Implementation of PACFISH standards and guides for Forest programs has been highly successful for passive upland and riparian restoration in this population's area.

The CREP program agreements are for durations of 10 or 15 years. There is no guarantee that the benefits and management actions will be continued beyond the duration of the agreements.

Table 9-2. Umatilla Subbasin Geographic Areas

GA	Stream	Segment	MaSA	MiSA
1	Umatilla River	Mouth to Three Mile Dam		
2	Umatilla River	Three Mile Dam to Butter Creek		
3	North Hermiston Drain	All		
4	Butter Creek	Mouth to Madison diversion	Butter	
5	Butter Creek	Madison Diversion to East Butter Creek	Butter	
6	Little Butter Creek	All	Little Butter	
7	East Fork Butter and tributaries	All	Butter	
8	Butter Creek	East Fork to Headwaters and Johnson Creek	Butter	
9	Umatilla River	Butter Creek to Westland Dam and Stanfield Dam to McKay Creek		
10	Stage Gulch	All		
11	Umatilla River	Westland Dam to Stanfield Dam		
12	Birch Creek	Mouth to forks including Stewart Creek		Birch, Stewart
13	West Birch Creek	Mouth to Bear Creek	West Birch	
14	Bear Creek	All, including tributaries	West Birch	
15	West Birch Creek	Bear Creek to top of gorge, including tributaries	West Birch	
16	West Birch Creek	Gorge to headwaters	West Birch	
17	East Birch Creek	Mouth to California Gulch	East Birch	
18	East Birch Creek	California Gulch to headwaters, including tributaries except Pearson Cr.	East Birch	
19	Pearson Creek	All	East Birch	
20	McKay Creek	Mouth to McKay Dam	McKay	
21	McKay Creek	McKay Dam to North Fork		
22	North Fork McKay	All, including tributaries	McKay	
24	McKay Creek	North Fork to headwaters, including tributaries	McKay	
25	Umatilla River	McKay Creek to Mission Bridge		
26	Wildhorse Creek	Mouth to Athena, including tributaries		Wildhorse
27	Widlhorse Creek	Athena to headwaters, including tributaries		Wildhorse
28	Umatilla River	Mission Bridge to Meacham Creek	Middle Umatilla	
29	Umatilla Tributaries	Mission, Cottonwood, Moonshine and Coonskin creeks	Middle Umatilla	
30	Buckaroo Creek	All	Middle Umatilla	
31	Iskuulpa Creek	Mouth to Bachelor Canyon	Middle Umatilla	
32	Iskuulpa Creek	Bachelor Canyon to headwaters, including tributaries	Middle Umatilla	
33	Meacham Creek	Mouth to North Fork	Meacham	
34	Meacham Creek	Tributaries from mouth to North Fork	Meacham	
35	North Fork Meacham	All, including tributaries	Meacham	
36	Meacham Creek	North Fork to Twomile Creek, including Sheep Creek	Meacham	
37	East Meacham	All including tributaries and Butcher Creek	Meacham	
38	Meacham Creek	Twomile Creek to headwaters, including Twomile Creek	Meacham	
39	Beaver Creek	All, including tributaries	Meacham	
40	Umatilla River	Meacham Creek to forks	Upper Umatilla	
41	Ryan Creek	All	Upper Umatilla	
42	North Fork Umatilla	Mouth to headwaters, including tributaries	Upper Umatilla	
43	South Fork Umatilla	Mouth to Thomas Creek	Upper Umatilla	
44	Buck Creek	All, including tributaries	Upper Umatilla	
45	Thomas Creek	All	Upper Umatilla	
46	South Fork Umatilla	Thomas Creek to headwaters, including Shimmiehorn Creek	Upper Umatilla	

Note: Minor spawning areas within the Umatilla Subbasin not represented include Cold Springs, Alkali, Speare, Mud Spring and Little McKay.

9.3.11 Habitat Strategies and Actions for Walla Walla River Steelhead Population

Primary limiting factors: high water temperature, sediment routing, impaired fish passage, degraded channel structure and complexity, degraded floodplain connectivity and function, and altered hydrology (low flow).

Primary threats: current land use practices that reduce habitat quality and quantity and disrupt ecosystem functions.

Several tables are included after the habitat strategies and actions for the Walla Walla River steelhead population. Tables 9-3 and 9-4 show priorities for steelhead habitat restoration and protection. This prioritization was developed by applying the Ecosystem Diagnosis and Treatment Model that determined limiting factors and the areas where the greatest increase in fish production could be realized from restoration and protection actions. Table 9-5 provides a cross reference of geographic areas and MaSAs/MiSAs.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Protect high quality habitats through acquisition, conservation easements and cooperative agreements	SF Walla Walla, Elbow to headwaters (1); SF Walla Walla Tribs (1) ; NF Walla Walla Little Meadows to headwaters (1); Walla Walla, Dry Cr. to Mill Cr.(2); Yellowhawk mainstem (2); Couse Cr. drainage (2)	Loss of habitat quantity and diversity, channel stability, sediment, low flow and high temperatures	Cultivation, forestry, grazing, urban development	Productivity, abundance	All	Agreements (conservation easements, cooperative agreements, etc.) could be made with private landowners in areas where priority habitats exist to maintain the current habitat values. Agreements in areas with priority habitats may include: Putting in no-cultivation riparian buffers on agricultural lands that are currently cultivated up to the channel's edge, increasing riparian buffer widths associated with forested areas, protecting unstable areas, or changing other types of management in riparian areas.
Implement Forest Practices Act	SF Walla Walla, Elbow to headwaters; SF Walla Walla Tribs; NF Walla Walla Little Meadows to headwaters; All are first priority (1)	Same as above	Forestry	Productivity abundance	All	
Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function	SF Walla Walla, mouth to headwaters (1); SF Walla Walla Tribs (1); NF Walla Walla mouth to headwaters (1); Walla Walla, Dry Cr. to forks (1); Yellowhawk mainstem (1); Couse Cr. drainage (1); Little Walla Walla System (2)	Same as above	Same as above	Productivity, abundance		Setbacks could include: no-cultivation riparian buffers on agricultural lands that are currently cultivated up to the channel's edge, increasing riparian buffer widths associated with forested areas, protecting unstable areas, or changing other types of management in riparian areas.

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Protect and conserve rare and unique functioning habitats	Upper South Fork Walla Walla (1)	Same as above	Same as above	Productivity, abundance	All	Priority areas can be identified and appropriate protective action can be taken.
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes	Subbasin-wide	Same as above	Same as above	Productivity, abundance	All	To prevent degradation of existing habitat, Best management Practices and existing laws that protect aquatic habitat should be applied across the subbasin with emphasis on areas of very high quality.
Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues	SF Walla Walla, mouth to headwaters (1); SF Walla Walla Tribs (1); NF Walla Walla mouth to headwaters (1); Walla Walla, Dry Cr. to forks (1); Yellowhawk mainstem (1); Couse Cr. drainage (1); Little Walla Walla System (2)	Same as above	Urban development	Productivity, abundance	All	Enforce existing land use laws that affect aquatic habitat and update laws that do not provide adequate protection.
Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance	SF Walla Walla, mouth to headwaters (1); SF Walla Walla Tribs (1); NF Walla Walla mouth to headwaters (1); Walla Walla, Dry Cr. to forks (1); Yellowhawk mainstem (1); Couse Cr. drainage (1); Little Walla Walla System (2)	Same as above	Urban development	Productivity, abundance	Productivity, abundance	Incorporating MCR steelhead priority habitat areas into the Natural Area Overlay Zone provision of the county development ordinance would allow the priority habitat areas to be protected while providing an expedient process for reviewing land uses.
Explore opportunities to incorporate priority areas into state legislation.	SF Walla Walla, mouth to headwaters (1); SF Walla Walla Tribs (1); NF Walla Walla mouth to headwaters (1); Walla Walla, Dry Cr. to forks (1); Yellowhawk mainstem (1); Couse Cr. drainage (1); Little Walla Walla System (2)	Same as above	Rural and urban development	Productivity, abundance	All	Examine opportunities to amend laws that would increase protection for priority habitat areas.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Protect high quality habitats through acquisition, conservation easements and cooperative agreements	CTUIR, ODFW, WWBWC, WDFW,TNC, RMEF, SWCDs, CD's	Ongoing	Water quality improvement have high dispersal downstream, stream corridor and function improvements would be confined to the specific site	Existing conservation agreements are complete. Full implementation of conservation measures will take 5-15 years or more	5 years to decades with passive restoration approaches	High, based on previous cooperative agreements
Implement Forest Practices Act and PACFISH	ODF, WDOE	Ongoing	Forest Practices Act applies to all commercial timber operations on private lands	Long term	Maintenance/improvement of existing conditions	High
Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function	CTUIR, ODFW, WDFW, WDOE, USFS, FSA, NRCS, SWCD, CD's, WWBWC	When need identified	Riparian areas associated with priority habitat areas	Long term	Immediate with continued improvement for up to 50 years. After 50 years habitat effectiveness will be maintained.	High

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.						
Protect and conserve rare and unique functioning habitats	USFS, BLM	Protection ongoing	Affected area	Long term	Immediate – maintain existing high quality conditions where found; maintain or improve existing conditions elsewhere	High
Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	USFS, BLM, SWCDs, WDOE, WDFW, ODFW, ODA, FSA, NRCS, CTUIR, ODSL, USACE, private landowners	Ongoing	All priority areas within the Walla Walla subbasin	Long term	Maintenance of existing conditions	High for federal lands; moderate elsewhere
Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues.	Municipalities, Counties	Unknown	Mid and lower subbasin; high dispersal downstream	Ongoing - unknown	Response is uncertain	It is unknown to what extent governments will address this need.
Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance	Counties, CTUIR, ODFW, WDFW	When possible	All priority areas within the Umatilla subbasin	Short term	Immediate with continued improvement for up to 50 years. After 50 years habitat effectiveness will be maintained.	Moderate, depends on implementation and enforcement
Explore opportunities to incorporate priority areas into state legislation.	ODFW, CTUIR, WDFW, WDOE	When funding is available and amendment is possible	All priority areas within the Umatilla subbasin	Long term	Immediate with continued improvement for up to 50 years. After 50 years habitat effectiveness will be maintained.	Low

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTUIR	CTUIR Walla Walla River Basin Anadromous Fish Habitat Enhancement Projects – Riparian Function		No	Yes, there is still potential for more conservation easements.
USFS	Roadless Areas		Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
ODF	Forest Practices Act			See State of Oregon programmatic review -- Appendix F.
BLM	South Fork Walla Walla ACEC		Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
USFS	PACFISH, Umatilla Forest Plan		Yes	Existing actions are adequate as implemented, but additional protection areas should be added as the need is identified.
CTUIR	Rainwater		Yes	Maintain current project.
USACE, ODSL	Waterway work permitting		No	Funding is not adequate.
ODA, SWCD	Walla Walla Ag.WQM rules			See State of Oregon programmatic review -- Appendix F.
SWCD/CDs/WWBWC/Tr-state Steelheaders	Watershed restoration		No	Programs have inadequate resources.
Municipalities	Land use ordinances		No	
Counties	Comprehensive plan		No	

Strategy 1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
FSA, NRCS, SWCD	CREP, CCRP, CSP, EQIP		Uncertain	The potential coverage of these programs has not been realized in Umatilla County.
OLCD	Statewide planning goals			See State of Oregon programmatic review -- Appendix F.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

CTUIR conservation easement programs have been effective at protecting and improving riparian habitat condition in the Walla Walla subbasin. There is potential for considerable expansion of this program. Emphasis should be placed on priority habitat areas for establishing easements.

The Umatilla National Forest should emphasize protecting priority areas during project planning and implementation. Ongoing management actions sufficiently protect high priority aquatic habitats. These existing protections should be continued. PACFISH/Forest Plan Programs per se are sufficiently protective for lands in current ownership and require changing management or increasing buffers only when need is identified site-specifically ("New" actions). Most of FS lands are already essentially fully protected under Forest Plan by protective management direction - Roadless and Wilderness and Wildlife Emphasis Management Areas that prohibit road building and forest practices except in rare circumstances; PACFISH protections apply to all such activities. When/if needs are identified; additional aquatic habitat could receive increased protective status and a "new action". Priority areas for habitat protection as listed above that reside within the Umatilla National Forest should be assessed as to whether administrative designations apply to the areas that will support protection of these areas over the long term. Adding additional wilderness areas and wild and scenic river segments would require designation by Congress.

Actions implemented under PACFISH on Federal lands allow for a near natural rate of recovery. An individual action may result in a short-term disturbance with minor effects. This assures that conditions are maintained over the long term.

While permit processes implemented by the US Army Corps are thorough and actions authorized are protective of aquatic resources, the program lacks personnel resources to insure that terms and conditions of permitted actions are followed. In addition, this agency lacks resources to adequately monitor waterways for non-permitted actions or act upon non-permitted situations reported by other agencies or private parties. See State of Oregon programmatic review -- Appendix F for ODSL.

The USFS land exchange program has the potential to bring existing private lands under federal ownership and PACFISH protections. However, this program is completely voluntary on the landowner's part and the landowner would acquire public land and could very likely lower standards of resource protection. The land exchange is, however, a tool that could be used under very controlled circumstances to see increased protection of important aquatic habitats. But the purpose of the program is focused on consolidating land holdings and not necessarily protection of habitat.

The Umatilla and Walla Walla Agricultural Water Quality Management (AgWQM) Area Rules require that management on agricultural lands allow the establishment, growth and maintenance of riparian or stream-side vegetation, consistent with site capability, to promote habitat and protect water quality by filtering sediment, stabilizing streambanks, naturally storing water, and providing shade. The AgWQM program is outcome-based rather than prescriptive, therefore allows landowners the flexibility to achieve water quality goals using available equipment, technology and innovation. The rules for each Management Area provide the enforceable backstop to the voluntary initiatives. The SWCDs are the local management agencies that provide the outreach, education and technical assistance. ODA is responsible for complaint investigations and enforcement actions. Technical and financial assistance is available through state and federal programs to landowners for establishing adequate riparian areas.

The CREP program agreements are for durations of 10 or 15 years. There is no guarantee that the benefits and management actions will be continued beyond the duration of the agreements.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Remove or replace barriers blocking passage such as dams, bridges, road culverts and irrigation structures	Priorities shown in Table 8-38. See Appendix G for the 22 culverts that need replacement.	Impaired fish passage	Dams, culverts, instream structures	Abundance, productivity, spatial structure, diversity	Primarily adults and 0+juveniles	A comprehensive on-the-ground survey of passage barriers in the Oregon portion of the subbasin has not been completed. All passage barriers in known steelhead habitat should be addressed in a prioritized fashion.
Construct ladders over existing permanent irrigation diversions	Priorities shown in Table 8-38	Impaired fish passage	Dams	Abundance, productivity, spatial structure, diversity	Primarily adults and 0+juveniles	
Operate and Maintain fish passage facilities	Diversions within current steelhead distribution are first priority (1)	Impaired fish passage and entrainment	Dams, culverts and Irrigation diversions	Abundance, productivity, spatial structure, diversity	All	There are cooperative projects in place in the Walla Walla subbasin to both physically maintain the facilities and provide biological oversight so they are operated to maintain optimum fish passage conditions.
Provide screening at 100% of irrigation diversions	Unscreened diversions within current steelhead distribution are first priority (1)	Impaired fish passage	Irrigation diversions	Abundance, productivity	All	In Oregon, all known gravity flow diversions are screened to NOAA criteria. It is not known to what extent that pump diversions are screened in the Oregon part of the subbasin. Pump diversions should be inventoried and addressed as soon as possible. The Little Walla Walla system is screened at the point of diversion, but diversions within this system where steelhead could be present, by swimming up the outlet in Washington, are not currently screened.
Replace screens that do not meet criteria	Diversions within current steelhead distribution are first priority (1)	Impaired fish passage	Irrigation diversions	Abundance, productivity	All	There are cooperative projects in place in the Walla Walla subbasin to maintain facilities and provide oversight so they are operated to maintain optimum fish passage conditions.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Remove or replace barriers blocking passage such as dams, bridges, road culverts	ODFW, CTUIR, WWBWC, CDs, TSS, road departments, private landowners	Ongoing	Fish access upstream of obstruction	Known issues addressed within 10 years	Immediate	High

Strategy 2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.						
and irrigation structures						
Construct ladders over existing permanent irrigation diversions	ODFW, CTUIR, WWBWC, CDs, TSS, private landowners	Ongoing	Fish access upstream of obstruction	Known issues addressed within 10 years	Immediate	High
Operate and Maintain fish passage facilities	CTUIR, ODFW, HBDIC, GFID,, private landowners	Ongoing	Facility site	ongoing	Immediate	High
Provide screening at 100% of irrigation diversions	ODFW, CTUIR, private landowners	Ongoing	Point of diversion	Status of most pump diversions unknown, remediation up to10-20 yrs	Immediate	High
Replace screens that do not meet criteria	ODFW, CTUIR, private landowners	Ongoing	Point of diversion	Status of most pump diversions unknown, remediation up to 10-20 yrs	Immediate	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTUIR	BPA Fish Passage program		No	More funding needed.
ODFW	Fish Screening Program		Yes, for gravity diversions	Need to inventory and address pump screening.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

It is currently unknown to what extent pump diversions in the Oregon portion of the subbasin are adequately screened. Pump diversion should be inventoried to determine screening status and all diversions screened to NOAA criteria. Washington currently has an initiative underway to provide landowners with funding to screen their diversions. This effort should be continued until all diversions are adequately screened. There is also a need for a comprehensive inventory of screening needs throughout the Oregon portion of the basin as this has not been done to date.

Table 8-38 is a list of known passage barriers in the Walla Walla subbasin in the area occupied by the Walla Walla steelhead population. These barriers should be addressed in a prioritized manner.

Strategy 3. Maintain and restore floodplain connectivity and function.

Strategy 3. Maintain and restore floodplain connectivity and function.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Reconnect floodplains to channels	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn (2).	Degraded floodplain, altered hydrology, altered sediment routing, degraded water quality	Removal of wetlands, side channels, off-stream habitat; conversion of floodplain for agricultural use; roads; loss of beaver dams	Abundance, productivity	All	Watershed scale problems and riparian management issues should be considered before active stream channel restoration is employed.
Reconnect side channels and off-channel habitats to stream channels	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn (2); Little Walla Walla System (2); Yellowhawk System (2).	Degraded floodplain, altered hydrology, habitat quantity and diversity,	Removal of side channels, off-stream habitat	Abundance, productivity	All	Channel reconstruction, placement of instream structures and large woody debris in concert with riparian restoration can be used to restore functionality of stream channels. Watershed scale problems and riparian management issues should be considered before active stream channel restoration is employed. In areas where direct and immediate

Strategy 3. Maintain and restore floodplain connectivity and function.						
						benefits to viability parameters can be addressed, large woody should be placed to improve ecosystem function. In areas where other habitat deficiencies, such as flow and water quality, also exist, restoration should focus on these other factors first.
Remove dikes and levies	Walla Walla R., Mill Cr. to forks (1)	Degraded floodplain connectivity, channel structure and complexity	Stream channelization, bank armoring	Abundance, productivity	All	Many streams in the subbasin are bordered by dikes and levies.
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	Subbasin-wide	Degraded floodplain connectivity, channel structure/complexity, flow, water quality, sediment	Loss of beaver dams	Abundance, productivity	all	

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Reconnect floodplains to channels	ODFW, WWBWC, SWCD, USFS, CTUIR, WDFW, BLM, Tri-state Steelheaders (TSS)	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Short term, once identified	Physical response will be immediate for some, others will develop over years to decades	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Reconnect side channels and off-channel habitats to stream channels	ODFW, WWBWC, SWCD, USFS, CTUIR, , WDFW, BLM, Tri-state Steelheaders	Ongoing	Effect on physical habitat features will be localized, but effects on water quality will have high dispersal downstream	Short term, once identified	Physical response will be immediate for some, others will develop over years to decades	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Remove dikes and levies	CTUIR, WWBWC, COE, private landonwers	When opportunity identified	Within the stream reach and reaches downstream for temp and sediment	10+ years	Improved stream and floodplain functions - Some benefits will be realized immediately and others will develop over years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	ODFW, WDFW, private landowners	Ongoing	Subbasin-wide	Long term	Undefined	High

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTUIR	BPA Habitat Program	Subbasin-wide	No	More funding needed.
SWCD, CD's, WWBWC/TSS	Watershed Restoration	Subbasin-wide	Uncertain	More funding/implementation needed.
ODOT, County road depts, Municipalities	Bridge maintenance	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
FSA, NRCS, SWCD, CD's	CREP, CCRP, CRP, EQIP	Subbasin-wide	Varies by program	Additional implementation needed.

Strategy 3. Maintain and restore floodplain connectivity and function.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
Intensive land uses within Walla Walla subbasin flood plains and upslope habitats have led to dramatic changes in waterway characteristics since arrival of Euro-American pioneers during the middle 1800's. The common outcomes of intensive land use activities in the subbasin include: 1) straight, incised channels with minimal woody riparian vegetation, and 2) wide channels with increased dynamics and minimal woody riparian vegetation. Site specific measures will be implemented within the context of an overall hierarchical strategy for prioritizing restoration actions. As implementation actions are planned, consideration will be first given to actions that address watershed processes and passive techniques, but artificial enhancement methods will be used where previous watershed assessment (2004) indicate that such work will lead to significant benefits for Mid-C steelhead and alternative approaches are not available.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural channel form	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature, flows	Stream channelization, bank armoring, large wood removal, loss of beaver damsl, removal of riparian vegetation areas	Abundance, productivity	All	Stream channel reconstruction and instream structures can be designed to correct channel stability problems. Where appropriate, passive treatments are preferred.
Place stable wood and other large organic debris in streambeds	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, water temperature	Removal of large wood, trees in riparian areas; channelization and streambank armoring, livestock grazing	Abundance, productivity	Fry to adult	Large, complex pools and riffle habitats with appropriate sized spawning gravels are missing within many areas. The preferred approach is to allow natural processes to restore these habitat elements. EDT has identified locations where significant benefit would occur if pools were introduced.
Stabilize and protect streambanks	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	Stream channelization, bank armoring, livestock grazing in riparian areas	Abundance, productivity	Eggs, fry and adults	Incised or over steepened stream channels that reduce riffle habitat should be repaired through passive and active approaches where water quality is currently adequate to support spawning and rearing.
Construct rock and log weirs to create pool habitats or elevate incised channels	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1)	Degraded channel structure and complexity, habitat diversity, sediment routing, flows	large wood removal, loss of recruitment trees in riparian area	Abundance, productivity	Fry to adult	Pools should be constructed strategically where other alternatives are not likely to accomplish this need, or constraints will not allow natural processes to form them. Artificial enhancement of pools should only be performed in areas where other parameters such as water quality would allow immediate use/benefit to be realized.

Strategy 4. Restore degraded and maintain properly functioning channel structure and complexity.						
Implement bridge maintenance BMPs	Subbasin-wide	Degraded channel structure and complexity	Stream channelization, bank armoring	Abundance, productivity	All	Many streams in the subbasin are bordered by dikes and levies.
Educate landowners on importance of LWD	Subbasin-wide	Loss of pool habitat, channel structure and complexity	Large wood removal	Abundance and productive	all	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural channel form	ODFW, SWCDs, CTUIR, WWBWC, CDs, WDFW, BLM	Ongoing; some needs identified in ODFW/CTUIR five-year action plan	Within the stream reach and reaches downstream for temp and sediment	25 years	Improved riparian vegetation and associated attributes and improved stream and floodplain structure and function; response time immediate to 10 years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Place stable wood and other large organic debris in streambeds	ODFW, WWBWC, CTUIR, CDs, WDFW, TSS, BLM	Ongoing as needed	Reach affected	Short term	Improved instream channel habitat diversity - Some benefits will be realized immediately and others will develop in 1-5 years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Stabilize and protect streambanks	ODFW, CTUIR, SWCD, CDs, WWBWC, BLM, private landowners	Ongoing; when specific opportunity identified	Within the stream reach and reaches downstream for temp and sediment	10+ years	Improved water quality – response time 1-5 years	High, but there is more risk with active restoration approaches in experiencing undesirable outcomes
Construct rock and log weirs to create pool habitats or elevate incised channels	ODFW, CTUIR, CDs, WWBWC, TSS	Ongoing; current action planned for Meacham Cr.	Treatment site	25 years	Increased quantity of pool habitat and channel and floodplain function – response time Immediate to 5 years	High over short term, however structures often require maintenance
Implement bridge maintenance BMPs	USFS, ODOT, WDOT, County road departments	Ongoing	Site specific	Long term	Improved LWD and water quality; slow response time	Moderate, depends on compliance with BMPs
Educate landowners on importance of LWD	Stellar, WWBWC, ODFW, BLM, CTUIR	Ongoing	Subbasin-wide	Long term	Variable lag time depending on actions	Moderate

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTUIR	BPA Habitat Program		No	More funding needed.
SWCD, CD's	Watershed Restoration		Likely	Involvement is currently limited. See State of Oregon programmatic review – Appendix F.
WWBWC/Tri-state Steelheaders	Watershed Restoration		No	There is a continuing need for landowner assistance to insure that issues are dealt with appropriately.
ODOT, County road depts.	Bridge maintenance			See State of Oregon programmatic review -- Appendix F.
FSA, NRCS, SWCD, CD's	CREP, CCRP, CRP, EQIP		Varies by program	Additional implementation needed.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

See discussion in Strategy 3, Walla Walla River population.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore natural riparian vegetative communities including vegetative planting	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded riparian area, channel stability, floodplain degradation, sediment, water temperature	Livestock grazing, channelization, stream bank armoring	Abundance, productivity, diversity	All	Historically, bank armoring with rock and channelization were used to stabilize stream banks at the detriment of riparian vegetation growth. In the last 15 years the high economic and ecological cost of bank armoring with riprap and of channelization has been recognized, so the emphasis has shifted toward a more passive approach for stabilization, primarily through riparian vegetation improvements and bioengineering treatments
Develop grazing strategies that promote riparian recovery	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded riparian area, channel stability	Livestock overgrazing of riparian area	Abundance, productivity, diversity	All	Grazing strategies, other than exclusion, should be developed to achieve riparian recovery in the next 10-15 years. Permanent or temporary exclusion of livestock from riparian areas remains the surest way to achieve riparian restoration where livestock have been the primary impact.
Develop no-cultivation riparian buffer on agricultural lands and establish riparian setbacks for structures in areas where activities could upset riparian function	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded riparian area, channel stability, floodplain degradation, sediment, water temperature	Degradation of riparian areas and function; residential development and cultivation	Abundance, productivity, diversity	All	In areas where development is occurring, that development should be adequately set back from streams so as not to interrupt natural stream processes. Ordinances pertinent to fish habitat and water quality must be enforced.
Riparian exclosure fencing	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded riparian area, channel stability	Livestock grazing	Abundance, productivity, diversity	All	Excluding livestock from riparian areas remains the most effective tool of mitigating livestock impacts.
Close, remove, and restore riparian road prisms	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded riparian area, channel stability, sediment	Roads	Abundance, productivity, diversity	All	In many areas of the Walla Walla subbasin, riparian roads have reduced riparian vegetation, confined stream channels, and continue to deliver fine sediment to channels. Relocat ing roads outside riparian and sensitive areas or eliminating roads from riparian and sensitive areas has a positive effect on steelhead habitat by allowing natural riparian processes to be restored.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.						
Protect high quality riparian habitats and unstable areas	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr. (1); NF Walla Walla R., mouth to Little Meadows Cyn. (1); Little Walla Walla System (2); Yellowhawk System (2)	Degraded riparian area, channel stability, floodplain degradation, sediment, water temperature	All	Abundance, productivity, diversity	All	

Action Implementation

Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore natural riparian vegetative communities including vegetative planting	CTUIR, NRCS/FSA, WWBWC, SWCD, CDs, TSS, private landowners	Ongoing	High dispersal downstream from site	25 years	Improved riparian vegetation and associated attributes – response time 5 years to decades	Moderate – plant survival varies based on techniques used
Develop grazing strategies that promote riparian recovery	ODA, NRCS, USFS, CDs, private landowners	Ongoing	High dispersal downstream from site	Long term	Improved riparian vegetation and associated attributes – response time 5 years to decades	Depends on diligence of management applications
Develop no-cultivation riparian buffer on agricultural in areas where activities could upset riparian function	CTUIR, ODFW, WWBWC, WDFW, WDOE, private landowners, TSS, FSA/NRCS	Ongoing	Cultivated land in close proximity to priority habitat areas within the Umatilla subbasin	Long term	Immediate with continued improvement for up to 50 years or until easement ends and management changes. After 50 years habitat effectiveness will be maintained.	High
Riparian exclosure fencing	CTUIR,ODFW, NRCS/FSA, WWBWC, SWCD, CDs, private landowners, TSS	Ongoing	High dispersal downstream from site	25 years	Improved riparian vegetation and associated attributes – response time 5 years to decades	High
Close, remove, and restore riparian road prisms	USFS, ODOT, WDOT, counties, private landowners	Ongoing	Riparian areas within the subbasin where potential for riparian road closure and removal exists	Based on opportunity and need	Improved water quality – response time immediate with continued response for up to 50 years	High
Protect high quality riparian habitats and unstable areas	CTUIR, ODFW, NRCS/FSA, BLM, SWCD, USFS, WWBWC, CDs	Ongoing	High dispersal downstream	Long Term	Depends on specific situation	High

Status of Existing Programs through which Actions are Implemented

Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODA, SWCD	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
FSA, NRCS, SWCD, CD's, WWBWC	CREP, CCRP, CSP, EQIP	Subbasin-wide	Varies by program	Greater participation by landowners is needed in Oregon. Many more stream miles to be treated. See State of Oregon programmatic review -- Appendix F.
ODFW	Fish Management Program	Subbasin-wide	Yes	
CTUIR	BPA Habitat Program		No	Many additional miles of stream need to be treated.
ODEQ	TMDL			See State of Oregon programmatic review -- Appendix F.
ODF	Forest Practices Act			See State of Oregon programmatic review -- Appendix F.
USFS, BLM	Grazing management, Forest Plan, Resource Management Plan, PACFISH		Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.

Strategy 5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.
Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
The Oregon Walla Walla River Water Quality Management Areas Plan (WQMAP) provides general guidance to landowners on management of riparian areas and there is some uncertainty regarding the implementation of this plan's requirements, as enforcement is based on a complaint-driven system. While there are ongoing programs to restore riparian vegetation, determination of limiting factors through use of the EDT model indicates that additional coverage is necessary. The Umatilla and Walla Walla AgWQM Area Rules require that management on agricultural lands allow the establishment, growth, and maintenance of riparian or stream-side vegetation, consistent with site capability, to promote habitat and protect water quality by filtering sediment, stabilizing streambanks, naturally storing water, and providing shade. The AgWQM program is outcome-based rather than prescriptive, therefore allows landowners the flexibility to achieve water quality goals using available equipment, technology and innovation. The rules for each Management Area provide the enforceable backstop to the voluntary initiatives. The SWCDs are the local management agencies that provide the outreach, education and technical assistance. ODA is responsible for complaint investigations and enforcement actions. Technical and financial assistance is available through state and federal programs to landowners for establishing adequate riparian areas. The CREP program agreements are for durations of 10 or 15 years. There is no guarantee that the benefits and management actions will be continued beyond the duration of the agreements.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Investigate feasibility of water storage or exchange to improve instream flows for steelhead	Walla Walla River, mouth to Little Walla Walla diversion (1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity	Parr to adult	
Close areas to appropriation of new water uses	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (2); NF Walla Walla R., mouth to Little Meadows Cyn (1). Little Walla Walla System (1)	Flows	Water withdrawals	Abundance, productivity, diversity	Parr to adult	Surface water flows are over appropriated in many areas of the Walla Walla subbasin. The various legal means available should be used to increase streamflows where assessments indicate that there is on-going take, or where steelhead production could be increased
File for additional ISWRs	Pine Cr. (2), Birch Cr. (1), Cottonwood Cr. (1), Walla Walla R. downstream of Little Walla Walla (1)	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity	Parr to adult	
Set criteria to protect flows for fish habitat from new appropriations	Subbasin-wide in Washington	Flows, water quality	Water withdrawals	Abundance, productivity	Parr to adult	High flow events are critical for maintaining quality instream habitat, and water quality. With increasing water demands for agricultural, industrial, municipal and domestic uses, the potential for mining of high flow increases. It is important that planners realize the importance of high flows for the maintenance of aquatic habitats and water quality, and that these flows are protected.
Improve irrigation conveyance and efficiency	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (2); NF Walla Walla R., mouth to Little Meadows Cyn (1); Little Walla Walla System	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity	All	
Enhance hyporheic flows and spring inputs	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (2); NF Walla Walla R.,	Flows, water temperatures, habitat	Water withdrawals	Abundance, productivity,	All	

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
	mouth to Little Meadows Cyn (1).	quantity/diversity		diversity, spatial structure		
Implement shallow aquifer recharge	Little Walla Walla system (1)	Flow, temperature	Water withdrawals	Abundance, productivity	All	While progress has been made, many streams t historically flowed year- long are now intermitten creating fish passage barriers in the dewatered reaches. Many of these are due to water withdrawals for agricultural, industrial, municipal and domestic uses.
Aquifer storage and recovery	Lower Mill Cr. (1)	Flow, temperature	Water withdrawals	Abundance, productivity	All	
Lease or acquire water rights and convert to instream	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (2); NF Walla Walla R., mouth to Little Meadows Cyn (1).	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity, spatial structure	Parr to adult	
Downstream water rights transfers	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (2); NF Walla Walla R., mouth to Little Meadows Cyn (1).	Flows, water temperatures, habitat quantity/diversity	Water withdrawals	Abundance, productivity, diversity	Parr to adult	
Monitor/regulate water withdrawals	Subbasin-wide (1)	Low flows, high temperatures	Water withdrawals	Abundance, productivity	Parr to adult	
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	Population-wide	Low flows, high temperatures	Water withdrawals	Abundance, productivity, spatial structure, diversity	All stages	New programs in development.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Investigate feasibility of water storage or exchange to improve instream flows for steelhead	USACE, CTUIR	Ongoing	Mid and lower Walla Walla	Uncertain	Improvements to flow depend on timing, magnitude and location of flow enhancement	Now in planning stage; actual implementation actions and potential funding are unknown
Close areas to appropriation of new water uses in Washington	WDOE	On hold	Affected reaches and downstream	Uncertain	Maintenance of existing conditions	High
File for additional ISWRs	ODFW, OWRD	On hold	Specific to the stream reach	Unknown	Maintenance of existing conditions	High, depends on how resource managers implement protection
Set criteria to protect flows for fish habitat from new appropriations	WDOE, WDFW	Ongoing	Affected reaches and downstream	Uncertain	Maintenance of existing conditions	Unknown
Enhance hyporheic flows and spring inputs	WWBWC, CTUIR, CDs	Ongoing	On site and downstream	Long term	Improved instream flow and water quality – response time depends on specific action	Depends upon specific approach used
Improve irrigation conveyance and efficiency	SWCD, WWBWC, private landowners, irrigation districts	Ongoing	Depends on means used to protect instream flows	Short term	Improved instream flow; response immediate	Moderate – depends on how saved water is protected, if any.
Implement shallow aquifer recharge	WWBWC, WDOE, HBDIC, GDID, WWRID, private landowners		Down gradient	Long term	Improved instream flow – uncertain response time	Undetermined

Strategy 6. Restore natural hydrograph to provide sufficient flow during critical periods.						
Aquifer storage and recovery	City of Walla Walla	Ongoing	Downstream of Mill Creek POD	Long term	Improved instream flow – uncertain response time	Long term effectiveness is unknown
Lease or acquire water rights and convert to instream	OWRD, Oregon Water Trust, water right holders	Ongoing, when opportunities arise	Depends on means used to protect instream flows	10-15 years	Immediate	moderate, depending upon how saved water is protected
Downstream water rights transfers	OWRD, private landowners, irrigation districts	Ongoing	Reach between old and new point of diversion	Long term	Improved instream flow; response immediate	High
Monitor/regulate water withdrawals	OWRD, WDOE	Ongoing	From the point of diversion downstream to the mouth of Walla Walla River	Long term	Maintenance or improvement of existing conditions; response to regulation immediate	Moderate, staffing levels are inadequate
Assess existing and future water needs, complete statewide inventory of above and below ground potential storage, complete assessment of conservation opportunities, provide incentive funding to develop strategies to meet long-term needs	OWRD	Ongoing	Population-wide	2007-2009 except incentive funding ongoing	Long term	Moderate

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
USACE, CTUIR	Flow Restoration Feasibility Study	Lower Walla Walla	Unknown	
OWRD	Streamflow Monitoring and Restoration, Flow Restoration, Lease/Transfer Water Rights, Administration of Water Rights, Water Use Measurement, Water Needs Assessment, Storage Assessment, Conservation Assessment	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
Oregon Water Trust, BPA	Leasing and Purchase of Water Rights	Walla Walla River	No	Needs expansion.
SWCD, Watershed Council, WWRID, HBDIC, GFID	Improve irrigation efficiency	Walla Walla R., Mill Cr. to forks; SF Walla Walla mouth to Elbow Cr; NF Walla Walla R., mouth to Little Meadows Cyn.	Varies by program	Needs expansion.
NRCS, Watershed Council	Upland improvements, riparian improvements	Subbasin-wide	No	Needs expansion.
ODF	Forest Practices Act	Subbasin-wide	Likely	See State of Oregon programmatic review -- Appendix F.
BPA	Columbia Basin Water Transaction Prgm	Walla Walla R., Mill Cr. to forks; SF Walla Walla mouth to Elbow Cr.; NF Walla Walla R., mouth to Little Meadows Cyn.	No	Needs expansion.
WDOE	Water Management Initiative	Walla Walla R., Mill Cr. to forks		

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

Significant progress has been made regarding flow issues on the mainstem Walla Walla River as a result of the Civil Penalty Agreement between the USFWS and three irrigation districts. However, significant flow issues remain along the Walla Walla River, NF Walla Walla R., Couse Cr., Dry and Pine creeks (Oregon) and Mill Creek. The Walla Walla subbasin has approximately 50 miles of stream protected by instream water rights. Voluntary flow restriction projects restored 4.4 cfs of flow in 2006.

The Walla Walla subbasin has approximately 50 miles of stream protected by instream water rights. Voluntary flow restoration projects restored 4.4 cfs of flow in 2006.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Address point sources of water pollution	Pine Creek (1), Walla Walla River (1)	Chemical pollution	Pesticides, fertilizers, herbicides	Abundance, productivity	All	Point sources of water pollution are direct impacts that should be corrected through implementation of the TMDL and associated water quality management plan.
Implement pest management plans for fruit growers	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (1); NF Walla Walla (1)	Water quality	Pesticides, fertilizers, herbicides	Abundance, productivity	All	
Improve municipal stormwater management and treatment	Walla Walla R., Mill Cr. to forks (1)	Water quality	Stormwater management	Abundance, productivity	All	
Permit waterway alteration activities and enforce rules	Subbasin-wide					
Implement water quality management plans	Walla Walla River (1)	Degraded water quality, flows, sediment routing, water quality	Land use practices, water withdrawals, pesticides, fertilizers, herbicides	Abundance, productivity	All	
Permit and enforce actions that could affect water quality	Subbasin-wide	Water quality	Land use practices,	Abundance, productivity, diversity	All	Directed actions at known sources of thermal pollution and sediment should be addressed through BMPs and improvement projects.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Address point sources of water pollution	ODEQ, WDOE	Ongoing	Subbasin-wide	Ongoing	Reduce chemical pollution immediately	High
Implement pest management plans for fruit growers	ODEQ, OSU, Ext. WWBWC, fruit growers	Ongoing	NF, SF, mainstem Walla Walla and Little Walla Walla system	Long Term	Reduced mortality of food items and issues with fish toxicology – minor response expected	Moderate
Improve municipal stormwater management and treatment	municipalities	Ongoing	Within city limits. High dispersal downstream	Long term	Improved water quality – immediate response	Uncertain
Permit waterway alteration activities and enforce rules	USACE, ODSL	Ongoing	Subbasin-wide	Ongoing	Variable lag time depending on actions	Moderate, current implementation of permit requirements are very specific and conservative
Implement water quality management plans	ODA, SWCD, Municipalities, CDs, USFS, BLM, ODF, Irrigation Districts, private landowners, Industry, ODEQ	Ongoing	High dispersal downstream	Ongoing	Immediate	Moderate – degree of implementation is uncertain

Strategy 7. Improve degraded water quality and maintain unimpaired water quality.						
Permit and enforce actions that could affect water quality	ODEQ, WDOE	Ongoing	Subbasin-wide	Ongoing	Variable lag time depending on actions	Ability of agencies to enforce water quality violations appears limited by staffing.

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
ODA, SWCD	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
FSA, NRCS, SWCD, CD, WWBWC	CREP, CCRP, CSP, EQIP	Subbasin-wide	Varies by program	Greater participation by landowners is needed in Oregon. Many additional miles of stream to be treated. See State or Oregon programmatic review – Appendix F.
CTUIR	BPA Habitat Program	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (2).; NF Walla Walla R., mouth to Little Meadows Cyn (1).	No	Many additional miles of stream to be treated.
USFS, BLM	Grazing management, Forest Plan, PACFISH	Upper Subbasin	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.
USACE/ODSL	Waterway work permitting	Subbasin-wide	Uncertain	See State of Oregon programmatic review -- Appendix F for ODSL.
ODF	Forest Practices Act	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODEQ	Water Quality	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODEQ, EPA	Pesticides/Toxics	Subbasin-wide		See State of Oregon programmatic review -- Appendix F for ODEQ.
Municipalities	Public Works		No	

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)

This threat is partially addressed by the Oregon Walla Walla River WQMAP, see discussion for Strategy in Section 5.

Implementation of PACFISH standards and guides for Forest and BLM programs, in conjunction with Forest Plan Management Area allocations, has been highly successful for passive upland restoration over most of this population's area.

The TMDLs set loading capacity to achieve water quality standards. To address high summer water temperatures, near stream vegetation disturbance, channel widening and low flows are the existing sources of increased solar radiation loading. Achievement of the TMDL targets is dependent of determination of system potential vegetation. During TMDL development, the best professional judgment of the team described the potential streamside shade-producing vegetation broadly, as continuous tree-belts on each side of the river.

While permit processes implemented by the US Army Corps of Engineers are thorough and actions authorized are protective of aquatic resources, the program lacks personnel resources to insure that terms and conditions of permitted actions are followed. In addition, this agency lacks resources to adequately monitor waterways for non-permitted actions or act upon non-permitted situations reported by other agencies or private parties. See State of Oregon programmatic review -- Appendix F for ODSL.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Strategic Actions and Impacts on Limiting Factors, Threats, and Population						
Actions	Geographic Locations (1-first priority, 2-second priority)	Factors Addressed	Threats Addressed	VSP Parameters Addressed	Life Stages Affected	Discussion
Restore native upland plant communities	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (1); NF Walla Walla R.,	Altered hydrology, sediment routing, channel stability,	Forestry, roads, overgrazing,	Abundance, productivity	All	

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
	mouth to Little Meadows Cyn (1).	floodplain and riparian area degradation, water quality	agricultural practices, noxious weeds			
Upgrade or remove problem forest roads	NF Walla Walla (1), SF Walla Walla (1)	Altered hydrology, sediment routing	Road network	Abundance, productivity	All	
Control noxious weeds through physical removal and chemical and biological agents	Subbasin-wide	Loss of native vegetation and watershed function	Noxious weed	Abundance, productivity	All	Control of noxious weeds is generally an issue that is not currently being addressed adequately at a regional scale.
Implement CREP and CCRP buffers	Walla Walla R., Mill Cr. to forks (1); SF Walla Walla mouth to Elbow Cr (1); NF Walla Walla R., mouth to Little Meadows Cyn (1)	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Agricultural practices	Abundance, productivity	All	
Initiate upland improvement demonstration projects	Subbasin-wide	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	All	
Conduct outreach to resource users and managers	Subbasin-wide	Altered hydrology, sediment routing, channel stability, floodplain and riparian area degradation, water quality	Upland land use practices	Abundance, productivity	All	
Demonstration projects to restore forest health and resilience to wildfire	Private and state forest lands	Altered hydrology, sediment, water quality, riparian functions, LWD recruitment	Conversion of vegetative communities	Abundance, productivity	All	Suppression of fires has altered fire regimes and increased threat of high intensity fires.
Apply BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	Subbasin-wide	Altered hydrology, sediment routing	Forestry, roads, overgrazing, agricultural practices, noxious weeds	Abundance, productivity	All	Upland land management practices affect the hydrologic function of the watershed, by causing rapid runoff rather than infiltration. BMPs should be implemented to insure that the watershed functions to its potential, given the anthropogenic influence in the watershed.

Action Implementation						
Actions	Implementing Entity		Spatial Coverage	Implementation Timeframe	Expected Biophysical Response Timeframe	Certainty of Outcome
Restore native upland plant communities	SWCD, USFS, NRCS, BLM, ODF, Counties, private landowners	Ongoing	Effects of higher precipitation infiltration rates will have high dispersal downstream	Long term		
Upgrade or remove problem forest roads	BLM, ODF, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term, many forest roads have legacy issues with regard to sediment transport and routing of runoff.	5-15 years	Moderate, although funding on public lands and landowner cooperation on private lands will determine rate of treatment
Control noxious weeds through physical removal and chemical and biological agents	County public works dept., public and private landowners, USFS, BLM	Ongoing	Subbasin-wide	Long term	Improvements to water quality expressed in decades	Uncertain. This is a broad landscape issue that is currently underfunded

Strategy 8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.						
Implement CREP and CCRP buffers	FSA, NRCS, SWCD, CDs, private landowners	Ongoing, when opportunities available	High dispersal downstream	Depends on funding availability	5 years to decades	High
Initiate upland improvement demonstration projects	ODFW, WDFW, NMFS, USFWS, USFS, BLM, CTUIR, WWBWC, WDOE, SWCDs, CDs, TSS	Ongoing	Entire subbasin	Long term	Variable lag time	Unknown, depends upon action taken as a result of being more informed
Conduct outreach to resource users, managers, general public	ODFW, WDFW, NMFS, USFWS, USFS, BLM, CTUIR, WWBWC, WDOE, SWCDs, CDs	Ongoing	Entire subbasin	Long term	Variable lag time depending on actions	Unknown
Demonstration projects to restore forest health and resilience to wildfire	ODF	Ongoing	Private and state forest lands	Long term	Variable 5-20 years	Moderate
Apply BMPs to forest practices including fuels management and fire suppression mitigation, livestock grazing, road management and agricultural practices	NRCS, ODF, USFS, BLM, WDOE, SWCD, CDs, ODA, CTUIR, private landowners	Ongoing	Reduced sediment and improved hydrologic function will have high dispersal downstream	Long term	Improvements to water quality expressed in years to decades; improvements in riparian vegetation and all associated attributes response time 5 years to decades	Moderate, depends on participation

Status of Existing Programs through which Actions are Implemented				
Agency/Organization	Program Name	Geographic Locations	Sufficient* (yes, likely, uncertain, no)	Sufficiency Rationale
CTUIR	Rainwater	Subbasin-wide	Yes	Maintain current project.
County Public Works	Weed Control	Subbasin-wide	No	Funding not adequate to meet the needs.
ODA	Agricultural Water Quality Management Program	Subbasin-wide		See State of Oregon programmatic review -- Appendix F.
ODF	Oregon Forest Practices Act	Private and state forest lands		See State of Oregon programmatic review -- Appendix F.
SWCD/CD's	Watershed restoration	Subbasin-wide	Uncertain	
FSA,NRCS, SWCD, CD's	CREP,CCRP,CRP,EQIP	Subbasin-wide	Varies	Needs more coverage. See State of Oregon programmatic review -- Appendix F for SWCD.
ODOT	Weed control	Subbasin-wide		Program reviewed in State assessment.
Municipalities	Public Works	Subbasin-wide	No	Additional improvements needed.
SWCD	Direct Seed Program			Additional landowner assistance needed.
USFS, BLM	Forest Plan, Resource Management Plan, PACFISH	Federal lands	Yes	See USFS/BLM Program Sufficiency Assessment -- Appendix E.

Program Sufficiency and Gaps (including current and near-term efforts, and additional efforts needed, constraints)
Additional effort is needed to protect native plant communities and associated watershed functions. Vegetation management across the watershed varies in approach widely.

Table 9-3. Restoration Priority Geographic Areas from the Walla Walla Subbasin Plan (NPCC 2004).

GA	Description
27	Walla Walla River, Mill Cr. to East Little Walla Walla
31	Walla Walla River, East Little Walla Walla to Tumalum Bridge
35	Walla Walla River, Tumalum Bridge to Nursery Bridge
36	Walla Walla River, Nursery Bridge to Little Walla Walla Diversion
37	Walla Walla River, Little Walla Walla Diversion to forks
41	South Fork Walla Walla, mouth to Elbow Creek
39	North Fork Walla Walla, mouth to Little Meadows Canyon (plus Little Meadows Can.)
3	Coppei Drainage
4	Touchet River, Coppei to forks
10	South Fork Touchet Mainstem
11	South Fork Touchet Tribs
6	North Fork Touchet Mainstem
7	North Fork Touchet Tribs (excluding Wolf Fork)
8	Wolf Fork, mouth to Coates (plus Robinson and Coates)
9	Wolf Fork, Coates to access limit (plus Whitney)

Table 9-4. Protection Priority Geographic Areas from the Walla Walla Subbasin Plan (NPCC 2004).

GA	Description
	All Priority Restoration Geographic Areas
43	South Fork Walla Walla, Elbow to access limit
45	Skiphorton and Reser Creek Drainages
42	Lower SF Wall Walla Tribs (Flume Canyon, Elbow)
44	Upper SF Walla Walla Tribs (excluding Skiphorton and Reser)
40	North Fork Walla Walla, Little Meadows to access limit (plus Big Meadows)
5	Patit Drainage
17	Walla Walla River, Dry to Mill
32	Yellowhawk mainstem (mouth to source)
	Headwaters**
38	Couse Creek Drainage

**Headwaters is an assemblage of reaches covering the bull trout bearing (present or potential) waters upstream of the present reaches designated through the EDT process.

Table 9-5. Walla Walla Subbasin Geographic Areas.

GA	Stream	Segment	MaSA	MiSA
1	Walla Walla River	Mouth to Touchet River		
2	Touchet River	Mouth to Coppei Creek	NA	NA
3	Coppei Drainage	Mouth to presumed Steelhead access limit	NA	NA
4	Touchet River	Coppei to forks, including Whiskey Creek	NA	NA
5	Patit Drainage	Mouth to presumed steelhead access limit	NA	NA
6	North Fork Touchet	Mouth to presumed steelhead access limit	NA	NA
7	North Fork Touchet tribs	Rodgers, Jim, Weidman, Lewis and Spangler creeks; all from mouths to presumed steelhead access limit	NA	NA
8	Wolf Fork	Mouth to Coates Creek; also includes Robinson Cr and Coates Cr; mouths to presumed steelhead access limit	NA	NA
9	Wolf Fork	Coates Cr to presumed steelhead access limit; also includes Whiskey Cr mouth to presumed steelhead access limit	NA	NA
10	South Fork Touchet	Mouth to presumed steelhead access limit	NA	NA
11	South Fork Touchet tribs	Dry Fork SF Touchet, Griffin Fork, North Griffin Fork, Beaver Slide, Green Fork and Burnt Fork; mouths to presumed steelhead access limits	NA	NA
12	Walla Walla River	Mouth Touchet River to Dry Cr, including Mud Cr mouth to presumed steelhead access limit		
13	Pine Creek	Mouth to presumed steelhead access limit and Swartz Cr mouth to presumed steelhead access limit	Pine	

GA	Stream	Segment	MaSA	MiSA
14	Dry Creek Drainage (Pine)	Dry Cr (trib to Pine) mouth to presumed steelhead access limit	Pine	
15	Lower Dry Cr	Dry Cr (trib to Walla Walla), mouth to Sapolil Rd crossing	Dry	
16	Upper Dry Cr	Dry Cr (trib to Walla Walla). Sapolil Rd crossing to confluence of NF and SF Dry creeks	Dry	
17	Dry Cr tribs	Mud Cr (trib to Lower Dry Cr) , Mud Cr (trib to Upper Dry Cr, NF Dry Cr and SF Dry Cr; mouths to presumed steelhead access limit	Dry	
18	Walla Walla River	Dry Cr to Mill Cr		
19	West Little Walla Walla	West Little Walla Walla River Drainage and Walsh Cr drainage		
20	Mill Cr	Mouth to start of US Army Corps of Engineers project at Gose St near Walla Walla	Mill	
21	Mill Cr	Gose St to Bennington Dam	Mill	
22	Mill Cr	Bennington Dam to Blue Cr and Titus Cr drainage	Mill	
23	Blue Cr Drainage	Mouth to presumed steelhead access limit and Little Blue Cr mouth to presumed steelhead access limit	Mill	
24	Mill Cr	Blue Cr to City of Walla Walla water intake	Mill	
25	Middle Mill Cr tribs	Henry Canyon Cr, Webb Canyon Cr, Tiger Canyon Cr; mouth to presumed steelhead access limit	Mill	
26	Mill Cr	City of Walla Walla Water intake to presumed steelhead access limit	Mill	
27	Upper Mill Cr tribs	NF Mill Cr, Low Cr, Broken Cr, paradise Cr; mouth to presumed steelhead access limit	Mill	
28	Walla Walla River	Mill Cr to East Little Walla Walla River and McEvoy Cr and Springbranch		
29	Garrison Cr Drainage	Includes Bryant Cr and all Walla Walla Urban streams	Cottonwood	
30	Stone Cr Drainage	All	Cottonwood	
31	East Little Walla Walla Drainage	East Little Walla Walla Drainage; Unnamed Spring; Big Spring Cr, mouth to presumed steelhead access limit		
32	Walla Walla River	East Little Walla Walla To Tumalum Bridge	Walla Walla	
33	Yellowhawk mainstem	Yellowhawk drainage mouth to source	Cottonwood	
34	Cottonwood Cr Drainage	Including NF, MF and SF, mouth to presumed steelhead access limit	Cottonwood	
35	Birch Creek Drainage	Mouth to presumed steelhead access limit	Walla Walla	
36	Walla Walla River	Tumalum Br to Nursery Br	Walla Walla	
37	Walla Walla River	Nursery Br to Little Walla Walla Diversion	Walla Walla	
38	Walla Walla River	Little Walla Walla Diversion to forks	Walla Walla	
39	Couse Cr	Mouth to presumed steelhead access limit	Walla Walla	
40	North Fork Walla Walla	Mouth to Little Meadows Canyon and Little Meadows Canyon mouth to presumed steelhead access limit	Walla Walla	
41	North Fork Walla Walla	Little Meadows Canyon to Big Meadows Canyon and Big Meadows Canyon mouth to presumed steelhead access limit	Walla Walla	
42	South Fork Walla Walla	Mouth to Elbow Cr	Walla Walla	
43	Lower SF Walla Walla tribs	Flume Canyon Cr and Elbow Cr, mouth to presumed steelhead access limit	Walla Walla	
44	South Fork Walla Walla	Elbow Cr to presumed steelhead access limit	Walla Walla	
45	Upper South Fork Walla Walla tribs	Bear Cr, Kees Canyon Cr, Burnt Cabin Gulch, Swede Canyon, Table Cr, Husky Spring Cr, Bear Trap Springs; mouth to presumed steelhead access limit	Walla Walla	
46	Skiphorton & Reser Creek drainages	Mouth to presumed steelhead access limit	Walla Walla	

Note: Minor spawning areas within the Walla Walla subbasin not represented include: Woodward Canyon, Switzler, Vansyckle Canyon, Juniper, Spring Valley and Below Spring Valley.

9.4 Hydrosystem Strategies and Actions

Hydropower system operations and configurations on the mainstem Columbia remain a major factor limiting the viability of the Mid-Columbia River steelhead DPS. The ICTRT (2006) ranked the mainstem hydrosystem as one of the key limiting factors. Tributary dams that provide hydroelectric power also block and/or impair steelhead passage and habitats in several populations.

9.4.1 Mainstem Columbia River Hydropower Operations and Configurations

Recovery strategies and actions address both configurations and operations of the Columbia River hydroelectric system. Actions range from improving passage at particular dams to addressing flow and temperature issues. The following mainstem hydropower strategies and management actions include actions from the May 2008 Biological Opinion for the Federal Columbia River Power System (NOAA Fisheries 2008), as well as additional and alternative actions recommended by the State of Oregon. It is the position of the State of Oregon that additional or alternative actions should be taken in mainstem operations of the FCRPS for ESA-listed salmon and steelhead. Some additional or alternative actions recommended by Oregon, while considered, were not included in the FCRPS action agencies' proposed action or NOAA's FCRPS Biological Opinion. At the time this proposed recovery plan was being finalized, Oregon was a plaintiff in litigation against various federal agencies, including NOAA, challenging the adequacy of the measures contained in the current FCRPS Biological Opinion. Mainstem hydrosystem actions that improve survival are considered high priority because the survival benefits will be realized by all populations in the Mid-C DPS. We have provided a summary of strategies and reasonable and prudent alternatives (RPAs) taken directly from the FCRPS BiOp followed by the additional and alternative actions sought by the State of Oregon.

> *Hydropower Strategy 1*: Operate the FCRPS to provide flows and water quality to improve juvenile and adult fish survival.
>
> RPA 4: The action agencies will operate the FCRPS storage projects for flow management to aid anadromous fish.
>
> RPA 5: The action agencies will operate the FCRPS run-of-river mainstem lower Columbia River and Snake River projects to minimize water travel time through the lower Columbia and Snake rivers to aid in juvenile fish passage.
>
> RPA 6: In-season water management via water management plans and by the Regional Forum.
>
> RPA 7: To address forecasting and climate change/variability the action agencies will hold annual forecast performance reviews and report on effectiveness of experimental or developing/emerging technologies.
>
> RPAs 8-9: Manage for operations and fish emergencies.

RPAs 10-13: Columbia River Treaty and non-Treaty storage management, agreements, and coordination.

RPA 14: Manage flow during dry years to maintain and improve habitat conditions for ESA-listed species.

RPA 15: The action agencies will continue to update the Water Quality Plan for Total Dissolved Gas and Water Temperature temperature in the mainstem Columbia and Snake rivers, and implement water quality measures to enhance ESA-listed juvenile and adult fish survival and maintain spawning and rearing habitat.

Hydropower Strategy 2: Modify Columbia and Snake river dams to maximize juvenile and adult fish survival.

RPAs 18-21: The Corps will prepare, in cooperation with NOAA Fisheries and co-managing agencies, configuration and operational plans for the Bonneville Project (2008), The Dalles Project, John Day Project (2008) and McNary Project (2009).

RPA 27: The action agencies will operate turbine units to achieve best fish passage survival (currently within 1% of best efficiency at mainstem dams on the lower Columbia and lower Snake rivers.

RPA 28: The Corps will implement structural improvements to adult passage at the mainstem Columbia River and Snake River projects.

Hydropower Strategy 3: Implement spill and juvenile transportation improvements at Columbia River and Snake River dams.

RPA 29: The Corps and BPA will provide spill to improve juvenile fish passage while avoiding high TDG supersaturation levels or adult fallback problems.

RPA 30: Continue the juvenile fish transportation program toward meeting system survival performance metrics.

Hydropower Strategy 4: Operate and maintain facilities at Corps' mainstem projects to maintain biological performance.

RPA 32: The Corps will prepare annually a fish passage plan in coordination with NOAA and the Regional Forum. The Corps will operate its projects year around in accordance with the criteria in the fish passage plan.

At the time this proposed recovery plan was finalized, it was the position of the State of Oregon that additional or alternative actions should be taken in mainstem operations of the FCRPS for ESA-listed salmon and steelhead.

The State of Oregon recommends the following additional and alternative actions to better address survival and recovery needs of Mid-Columbia steelhead (see State of Oregon (2008) comments on Draft 2007 FCRPS Biological Opinion and State of Oregon's Supplemental Complaint-In-Intervention For Declaratory and Injunctive Relief (July 22, 2008) for detailed actions included here by reference).

- Draft storage reservoirs to meet lower Columbia summer flow and velocity equivalent objectives on a seasonal and weekly basis.
- Operate reservoirs at rule curves and seek additional flow augmentation volumes from Snake River and Canadian reservoirs to better meet spring and summer flow and velocity objectives.
- Operate John Day reservoir at minimum operating pool during spring and summer as long as barge transport and irrigation needs are met.
- Provide spill to total dissolved gas limits of water quality waivers or biological constraints at all dams, except maximize transportation at Snake River collector projects during lowest (10^{th} percentile) flow years.
- Maintain approximately 50/50 in-river and transportation proportions for spring and summer migrants in the Snake River by optimizing spill and surface-oriented routes of dam passage and transporting fish collected in the turbine screen bypass systems.
- Continue to provide spill and bypass all fish at McNary Dam at all flows during the spring migration period.
- Before reducing full spill, test removable spillway weirs and temporary spillway weirs to ensure they provide equal or better benefits than full spill.
- Establish more rigorous research, monitoring, and evaluation to assure that fish survival is increasing and to inform adaptive management.
- Identify and prepare contingency actions for implementation if necessary to meet fish performance standards linked to survival and recovery requirements of listed fish.

9.4.2 Tributary Hydropower Operations and Configurations

Hydropower development and operations affect the viability of four existing Mid-C steelhead populations in Oregon: Deschutes River Eastside, Deschutes River Westside, Umatilla River and Walla Walla River. The dams are also key factors affecting the potential recovery of now extinct steelhead populations in the Crooked River and Willow Creek systems.

Deschutes River Populations
The following strategies and actions are for the Deschutes Westside, Deschutes Eastside and extinct Crooked River populations. They focus on developing effective downstream collection and passage of steelhead smolts through the Pelton-Round Butte Complex on the Deschutes River. The passage strategy at the complex is to construct a Selective Water Withdrawal (SWW) and a Fish Collection Facility. The SWW is designed to modify flow patterns in the reservoir so that fish will be attracted to the entrance of the facility during their out-migration. The fish will them be enumerated, marked and transported to the lower Deschutes River, to continue their out-migration. The construction of the selective water withdrawal is scheduled for completion in 2009. The SWW will also have an intake near its bottom, so it can draw cold water during summer and fall to mix with warmer surface water. This will maintain appropriate downstream

temperatures in the lower Deschutes River. An adaptive management strategy will continue to be used to implement facility improvements based on monitoring and evaluation with the goal of achieving high passage efficiencies at the barrier.

Strategy 1: Restore sustainable natural steelhead production to blocked habitats in the Deschutes River Westside, Deschutes River Eastside, and the extinct Crooked River populations.

Management actions

1. Develop effective downstream collection and passage for smolts through the Pelton-Round Butte Complex.
2. Improve flow patterns through the reservoir to provide effective juvenile migration.
3. Modify Pelton-Round Butte Complex operating procedures to restore downstream water quality to meet State and Tribal water quality criteria.

Success in re-establishing runs of summer steelhead above Pelton-Round Butte Complex will depend substantially on the degree to which the new SWW and fish collection facility enable the steelhead to migrate effectively from the mouths of tributary streams and past Lake Billy Chinook during their out-migration. Adaptive fish management and improvements to altered streams above LBC will both be important, but effective fish passage through the reservoir will be a necessary prerequisite to any success in establishing runs that can sustain themselves. With this in mind, reintroductions of steelhead will occur in two phases. Phase 1 will emphasize introductions of pathogen-screened juveniles above Pelton-Round Butte Complex, to test the ability of the new SWW facility to change surface currents in LBC and collect out-migrant smolts. Actions taken during Phase 1 will also (1) begin to test recent estimates of fish production potential in habitat above Pelton-Round Butte Complex, (2) examine fish stock performance in the available habitat, (3) continue rehabilitating altered habitats, and (4) produce modest returns of adult fish. When smolt passage through LBC and into the fish collection facility meets agreed-upon measures of success[1], the reintroduction program will transition into Phase 2 in which adults returning to the upper basin (i.e., after rearing as juveniles above Round Butte Dam) are passed upstream and continued releases of pathogen-screened juveniles into the upper basin will use fish of the fittest lineages available. The exact timing and/or duration of shifts toward more or less intense releases of juvenile fish during this second phase of the reintroduction effort may differ for each subbasin.

Reintroduction Phase 1. During Phase 1 of the reintroduction effort for summer steelhead, the numbers of fish released into specific upper basin streams will be based on interactions between

[1] Measures of success include changes in reservoir surface currents, effective migration patterns of radio-tagged smolts (a biological response to the currents), and passage efficacy of about 50 percent for one or more species from one or more arms of the reservoir. The 50 percent reservoir survival target identified in the Settlement Agreement and in Table 4-1 of this Plan was originally intended to be a trigger for constructing permanent downstream passage facilities at Round Butte Dam, not as the single determining factor for permitting upstream adult passage at PRB. Consistent with adaptive management provisions included in the Settlement Agreement the decision to make the transition to upstream adult passage of known-origin fish will be based on numerous indicators and mitigating factors, and will be well-founded on sound biological principles. The indicators will include the 50 percent survival value, a value that modeling by Beamesderfer (2002) suggested was an approximate threshold for population sustainability.

statistical needs of fish passage studies (Skalski and Townsend 2007), habitat capability (Cramer and Beamesderfer 2006), and realistic assumptions about the opportunity to trap smolts after they have been produced in habitats above the reservoir. In the watersheds (Whychus Creek, and/or Crooked River) where it is reasonable to expect that adequate numbers of naturally-reared smolts could be produced, trapped, and marked prior to entering Lake Billy Chinook, fry releases will meet or exceed those estimated to be needed to produce the required numbers of marked naturally produced smolts for reservoir passage tests. Where fry releases into a particular major subbasin appear unlikely to provide enough naturally-produced smolts to meet the statistical demands of fish passage tests, releases will be less intense but sufficient to begin testing habitat suitability, begin evaluating fish performance, and (potentially) to produce small numbers of returning adults.

During Phase I there will also be direct releases into the upper basin of tagged hatchery-produced smolts that have been pathogen-screened. These fish will be given unique marks that can be distinguished from naturally-reared smolts , and released in numbers that will be large enough to meet the statistical demands of reservoir passage tests for smolts leaving each of the three major subbasins tributary to Lake Billy Chinook. Releases of hatchery smolts for reservoir passage tests will either provide information supplemental to that obtained from tests of naturally reared smolts or enable statistically meaningful passage tests where they would otherwise be infeasible.

Each naturally-reared smolt that successfully negotiates Lake Billy Chinook and leaves the upper basin via the SWW facility during Phase 1 will either be given a PIT-tag or will be marked with unique fin clips. The PIT-tags will allow additional data collection on fish as they migrate to and from the ocean. The tag or unique fin clips will allow managers to assure that the fish will (1) avoid directed harvest and therefore experience lower harvest rates as they pass through fisheries when returning as adults, and (2) be identified as having upper basin origins when they arrive as adults at the Pelton Trap. Naturally-reared adults arriving at the trap will be passed upstream during Phase 2.

Reintroduction Phase 2. The criteria for moving from Phase 1 to Phase 2 is when 50% of the smolts captured at one of the reservoir arms migrating through Lake Billy Chinook are subsequently recaptured at the SWW fish collection facility. Once this criteria is reached the reintroduction program will transition into Phase 2. In this phase adult fish returning to the Pelton Trap, after having reared as juveniles above Pelton-Round Butte Complex, will be passed into the upper basin, including those fish that reared in the upper basin during Phase 1. A small fraction of the returnees may be used as broodstock. Natural-origin fish will be used during Phase 2 if possible.

Fish releases above Round Butte Dam during this phase of the program will be intended to develop locally adapted populations, with the numbers of young fish released into specific upper basin areas reflecting information acquired on the developing anadromous runs. As an early approximation, releases of fry during the first fish generation of Phase 2 will be of magnitudes estimated to be sufficient by themselves to produce about 50 percent of the maximum smolt carrying capacity of a particular stream. If the number of returning adults and the anticipated progeny exceeds expectations, the percentage of fry released will be reduced. This first cycle of fry releases during Phase 2 will also be supplemented with releases of hatchery smolts produced

from natural-origin broodstock, if smolts can be produced from an appropriate group of parents. Fry releases after the first fish generation of Phase 2 will diminish as rapidly as can be justified, to avoid a situation in which an extended hatchery supplementation program works against natural selection processes. During Phase 2 of the reintroduction effort, fish releases into the upper basin will be consistent with the suitability and productive capacity of available habitat. If habitat in a particular area proves to have greater capacity than initially predicted, fish releases there might be adjusted upwards, depending on broodstock availability. If habitat has less capacity, greater emphasis will be placed in the near term on habitat rehabilitation efforts and fish releases may be adjusted downward until habitat improves.

Marking of smolts at the SWW facility will continue until disease or other concerns have been addressed sufficiently to allow all adult fish arriving unmarked at the Pelton Trap (those natural-origin fish that are either returning to the upper basin or migrating toward areas other than the spawning locations of their parents) to be passed upstream.

Umatilla River Population
The following strategy and actions address flow and passage problems due to hydrosystem operations and facilities at the Boyd Hydro Project between RM 9-10 on the Umatilla River.

Strategy: Improve hydrosystem operations and facilities at the Boyd Project to reduce impacts.

Management actions
1. If possible, bypass reach flows for the Boyd Hydro Project should be modified to mimic the instream water right.
2. Fish passage facilities associated with the dam should be modified to meet current ODFW and NMFS fish passage standards.
3. Implement timely removal of weir panels from the diversion dam during period of non-operation to facilitate upstream passage.
4. Conduct timely and thorough maintenance of trash racks during periods of non-operation.

Walla Walla River Population
The following strategy and actions improve operations at Twin Reservoirs Hydro Project in the Walla Walla drainage.

Strategy: Improve hydrosystem operations and facilities at Twin Reservoirs Project to reduce impacts.

Management action
1. Conduct an assessment of the fishway at the dam. If the fishway does not meet ODFW standards, then it should be modified to meet standards for passage of juvenile fish.

9.5 Estuarine and Plume Habitat Strategies and Actions

The complex relationships that exist between species and habitat conditions in the Columbia River plume, estuary, and lower mainstem are poorly understood. The Columbia River Estuary

Recovery Plan Module (LCREP 2006) identifies 23 management actions that, together, address the range of threats salmonids in the estuary face including: altered habitat-forming processes; altered habitat structure in the estuary; changes in the food web dynamics; and poor water quality. The Mid-C Expert Panel identified impacts of bird predation in the estuary as a secondary threat in the past and present land use threat category. Based on our guidance, actions in the estuary that provide survival benefits are considered high priority because the benefits would likely be realized by all populations in the Mid-Columbia River steelhead DPS. Actions addressing predation concerns are shown in Section 9.7.

Strategy: Restore degraded estuarine and plume habitats and associated ecological processes.

Management actions
The following management actions that were identified by the LCREP (2006) are considered important to the survival of Mid-C steelhead during their migration and residency in the estuary and plume.

1. Protect intact riparian areas in the estuary and its tributaries and restore riparian areas that are degraded.
2. Modify hydrosystem operations to reduce the effects of reservoir surface heating, or conduct mitigation measures.
3. Adjust the timing, magnitude and frequency of flows (especially spring freshets) entering the estuary and plume to provide better transport of sediments and access to habitats in the estuary, plume, and littoral cell.
4. Remove pile dikes that have low navigational value but high impact on estuary circulation and/or juvenile predation effects.
5. Protect remaining high-quality off-channel habitat from degradation through education, regulation, and fee simple and less-than-fee acquisition.
6. Breach or lower dikes and levees to improve access to off-channel habitats.
7. Identify and implement actions to reduce salmonid predation by pinnipeds.
8. Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.
9. Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.
10. Identify and reduce industrial, commercial, and public sources of pollutants.
11. Monitor the estuary for contaminants and/or restore contaminated sites.

9.6 Harvest Strategies and Actions

Harvest strategies and actions address threats to Mid-C steelhead from mainstem Columbia River and tributary fisheries. Few steelhead from any Columbia River populations are caught in ocean fisheries under current management regulations.

9.6.1 Mainstem Harvest

We have not proposed any actions related to mainstem harvest, which we considered a secondary threat to Mid-C steelhead. We have, however, identified a strategy that should be adopted within

the management regulation processes to implement actions in those fisheries that pose the most significant threats to Mid-C steelhead in Oregon. New harvest biological opinions will come into effect starting in 2008 and the following strategy should be considered.

Strategy: Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.

9.6.2 Tributary Harvest

The current level of impact of tributary sport fisheries in all populations is quite low, thus we have concluded that tributary fisheries do not pose a significant threat to viability of any Mid-C populations. Additional harvest management actions are recommended, however, to address threats from the straying of out-of-subbasin hatchery steelhead in the Deschutes River and John Day River populations.

Fifteenmile Creek Population
No additional harvest actions are necessary, as long as current regulations continue to be implemented.

Deschutes River Westside and Eastside Populations
Fishery impacts on adult and juvenile steelhead in the Deschutes River have been minimized under the fishing regimes established in the FMEP. The following harvest strategy addresses threats from out-of-subbasin hatchery steelhead strays.

Strategy: Utilize harvest to reduce the abundance and proportion of stray hatchery spawners.

Management action
1. Develop an educational outreach program to promote the use of selective recreational fisheries to reduce the number of out-of-subbasin hatchery strays. Action is designed to increase the removal of hatchery steelhead in the fisheries by promoting the increased retention of hatchery fish caught in the fisheries. Currently, many anglers release marked hatchery fish that have been hooked and landed. Fisheries managers should encourage retention of hatchery steelhead by developing an education outreach program describing the benefits to the natural populations from the retention of marked hatchery fish.

John Day River Populations
Overall, fishery impacts on adult and juvenile steelhead in the John Day River have been minimized under the fishing regimes established in the FMEP. Harvest is proposed as a tool to address the current threat from out-of-subbasin hatchery steelhead strays.

Strategy 1: Utilize harvest to reduce the abundance and proportion of stray hatchery spawners.

Management action
1. Develop an education outreach program to promote the use of selective recreational fisheries to reduce the number of out-of-subbasin hatchery strays. Action encourages

retention of all hatchery fish caught in the fisheries. Currently, a large number of anglers continue to release marked hatchery fish that have been hooked and landed. Fisheries managers should develop an education outreach program describing the benefits to the natural populations from the retention of marked hatchery fish.

Strategy 2: Reduce catch and release mortality on natural-origin fish.

Management action

1. Promote a voluntary curtailment of fishing at higher water temperatures (above 21° C) as a measure to reduce hook-and-release mortality. Action addresses potential fisheries impacts for steelhead in the John Day River subbasin when water temperatures are over 21° C. This may occur at the opening of the steelhead fishery in September primarily in the lower section of the river below Cottonwood Creek that is open year around.

Strategy 3: Improve quality of harvest and natural-origin fish.

Management action

1. Expand the creel surveys to monitor fisheries effort and catch in the areas from Tumwater upriver to the area deadline. In addition to the effort and catch data, creel surveys could be used to recover tagged hatchery steelhead and as a mechanism to communicate with the public regarding management actions 1 and 2 above. The surveys, in combination with increased marking of Columbia River Basin hatchery steelhead, should provide better data of location of recovery and origin of hatchery strays.

Umatilla River Population

Fisheries are believed to have a relatively small impact on steelhead in the Umatilla River as managed under regulations described in the FMEP and CTUIR regulations. Tributary fisheries are not considered a threat to viability of the Umatilla River steelhead population. Consequently, no additional harvest actions are proposed for the Umatilla River at this time.

Walla Walla River Population

Current fisheries are not considered a threat to viability of the Walla Walla River steelhead population as managed under the current FMEP and CTUIR fishing regulations. Because of the relatively small impact rate of the fisheries, no additional actions are recommended.

9.7 Hatchery Strategies and Actions

Strategies and actions address ecological and genetic effects resulting from current hatchery management programs in and outside the DPS.

9.7.1 Overall Hatchery Strategy and Actions

We are proposing a number of management actions that address impacts to Oregon Mid-C steelhead populations from hatchery programs outside the DPS that are providing the source of out-of-DPS strays. These management actions are common to all Mid-C populations and are therefore presented in this section. Unlike management actions for all the other H's, in some

cases the Sounding Board could not reach consensus on the proposed hatchery actions. We present all the alternatives that were considered and characterize each recommendation as either a consensus or non-consensus recommendation. In addition, we provide information related to concerns expressed by the Sounding Board members who could not support specific recommendations. Many of the proposed actions will require development of agreements within the Columbia Basin decision, management and funding processes, such as, US vs. Oregon, BiOp Remand, and the Lower Snake River Compensation Plan Program.

The Hatchery Scientific Review Group completed a review of Oregon's Mid-C steelhead population hatchery programs and released their recommendations on January 31, 2009 (HSRG 2009). The HSRG report was released after this recovery plan, including proposed management actions, was released for public comment in the Federal Register. We provide a comparison of the HSRG recommendations with the recovery plan proposed actions for each population to assess the degree of consistency.

Strategy: Reduce the uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish.

Management actions

1. Implement a representative coded-wire-tagging program so that all hatchery stocks have adequate CWT groups released on an annual basis. [This will improve the ability to determine origin of strays in all populations. This is a consensus recommendation.]
2. Mark all hatchery steelhead releases in the Columbia River Basin with, at a minimum, an adipose clip or other distinguishing mark. [This action would facilitate recognition of hatchery fish at weirs and on the spawning grounds providing for removal and better hatchery proportion estimates. This is a non-consensus recommendation.]
3. Recommend development of alternative broodstocks that will stray at lower rates for the hatchery programs that contribute significantly to the stray problem. [Currently, ODFW is evaluating an alternative broodstock approach for the Wallowa stock, which strays at high rates, to specifically reduce straying into Mid-C populations. If this alternative broodstock management strategy proves successful it should be considered for other Snake River steelhead hatchery programs. This is a consensus recommendation.]
4. Reduce the proportion of Snake River hatchery smolts that are transported from Lower Granite and Little Goose dams. [Recent evidence from Perry et al. (2006 unpublished data) indicates that transported smolts may stray at significantly higher rates than in-river migrants. There are limited data available to examine the relationship. This is a non-consensus action that the Sounding Board indicated should be examined in more detail when additional data are available.]

9.7.2 Tributary Hatchery Strategies and Actions

Out-of-subbasin hatchery strays were identified as a key threat to a number of Mid-C populations. In addition, hatchery fish escaping and spawning naturally in the Walla Walla population was also identified as a key threat. There is lesser concern regarding the impacts of the Round Butte Hatchery program and the Umatilla Hatchery Program on populations in these subbasins.

Fifteenmile Creek Population

There are no plans to use artificial propagation to support fisheries or enhance natural production in the Fifteenmile Creek subbasin. Consequently, the main hatchery-related threat to the Fifteenmile steelhead population is from out-of-DPS strays. However, since the source of most hatchery fish passing Fifteenmile Creek are summer steelhead, there is little chance of introgression. There was considerable uncertainty in the proportion of hatchery fish in the natural spawner estimates for viability assessment. The Mid-C Expert Panel did not identify this as major risk for Fifteenmile Creek winter and steelhead; however, it could become a factor in the future if improved water quality attracts stray hatchery fish into the subbasin.

Strategy: Reduce uncertainty in abundance and proportion of hatchery strays spawning naturally.

Management action

1. Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys.

   Additional surveys would increase the precision of the current estimates. Information gathered would be used to provide a better estimate of the hatchery fraction. This is a consensus recommendation.

The HSRG recommendations are entirely consistent with the proposed actions for the Fifteenmile Creek population.

Deschutes River Eastside Population

Actions are proposed within the Deschutes River subbasin to address hatchery-related threats resulting from stray out-of-subbasin hatchery steelhead.

Strategy 1: Reduce the abundance and proportion of stray hatchery fish that spawn naturally.

Management actions

1. Construct trapping facilities in Buck Hollow and Bakeoven creeks and conduct a study to determine the effects of hatchery strays on production, productivity, and life history. A detailed study proposal has been completed to conduct a control-treatment study in Buck Hollow and Bakeoven. Once the study is completed Facilities can be used to remove strays. This is a consensus recommendation.

2. Improve trapping facilities and expand trapping operations on Trout Creek to trap and remove all strays.

   This is a consensus recommendation.

3. Modify and operate the trap at Sherars Falls to collect and remove out-of-subbasin hatchery fish which will reduce the number of hatchery steelhead that could spawn naturally.

This action has substantial cost and would result in the handling of most of the Deschutes natural-origin fish. In addition, there are considerable social concerns of how best to deal with the trapped strays. The Sounding Board concluded that this action should be reconsidered at a later time after all the other hatchery actions in the Deschutes populations had been implemented and evaluated.

Strategy 2: Reduce uncertainty in abundance and proportion of hatchery strays spawning naturally.

Management action

1. Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys.

   Additional surveys would increase the precision of current estimates. This is a consensus recommendation.

   The HSRG recommendations are entirely consistent with the proposed actions for the Deschutes River Eastside population.

Deschutes River Westside Population

Hatchery actions for the Deschutes River Westside population aim to improve the Round Butte Hatchery summer steelhead program and address concerns regarding out-of-subbasin strays. The ICTRT and the Mid-C Expert Panel consider straying of out-of-DPS hatchery steelhead a key threat to steelhead in the Deschutes Westside population. In addition, we identified stray hatchery steelhead as a high risk for the diversity metric in the viability assessment. Strategy 1 and Strategy 2 are specific to the Westside population. Actions in Strategy 3 are proposed to support steelhead reintroduction above the Pelton-Round Butte Complex to restore sustained natural production.

Strategy 1: Reduce the genetic risks associated with the Round Butte Hatchery Program.

Management action

1. Investigate opportunities and risks associated with incorporating naturally produced Deschutes River summer steelhead into the RBH broodstock.

   The current practice of using only known RBH summer steelhead for broodstock has the potential for the RBH program steelhead to diverge from the naturally produced Westside steelhead population. This divergence can lead to potential adverse genetic effects from naturally spawning RBH summer steelhead. Methods to genetically identify Deschutes River origin steelhead will need to be developed to insure that only naturally produced steelhead from within the population are used in the broodstock. This is a consensus recommendation.

Strategy 2: Reduce the abundance and proportion of stray hatchery fish that spawn naturally.

Management action

1. Begin collecting and removing hatchery steelhead at the Shitike Creek Trap.

   The trap is currently used to monitor the reproductive success of hatchery spring Chinook salmon and evaluate bull trout life histories. The trap needs to be modified to support more efficient collection and removal of hatchery steelhead. The current trapping effort is planned to stop in a few years. There are concerns regarding the logistic feasibility and costs of building and operating a more permanent structure. This is a consensus recommendation.

Strategy 3: Restore natural production to blocked areas above Pelton-Round Butte Complex (for both Westside and Crooked River populations).

Management action

1. Develop and implement a comprehensive plan for the reintroduction of steelhead into the upper Deschutes River subbasin above the Pelton-Round Butte Complex.

   Hatchery production will play a crucial role during the initial phases of reintroduction. The hatchery will operate with dual objectives: (1) produce fish for harvest mitigation and (2) produce fish to achieve conservation objectives. Under the conservation objectives, (OAR 635-007-0545(11)), goals associated with reintroduction would aim to meet objectives for supplementation and restoration to areas upstream of the complex.

   Round Butte Hatchery stock steelhead will be used for initial steelhead releases due to their availability and to concerns with impacts of collecting native stock steelhead. Native stock steelhead will be used once it has been determined that passage efficiencies through the complex are suitable. A genetic assessment has been initiated to characterize Deschutes River steelhead and redband trout populations. Results from this work will be used to help identify appropriate broodstock for reintroduction. This approach, including a reduction of hatchery releases as naturally produced fish return, should lead to an adapted and productive natural steelhead stock.

   Steelhead fry or smolt releases will provide the primary means to re-establish adult returns to historical habitats during Phase 1 of reintroduction. Initial efforts to reintroduce steelhead will focus most strongly on productive habitats along Whychus Creek. Whychus Creek once supported steelhead runs in the range of about 500-1,000 adults, and was by far the strongest producer of these fish when passage efforts at Round Butte were abandoned in the late-1960s (ODFW and CTWSRO 2007). No steelhead will be released directly into the mainstem Deschutes River above the complex and in the Metolius subbasin because habitat in these areas is thought to be better suited to resident rainbow trout than to steelhead (Cramer and Beamesderfer 2006). Colonization of this habitat by steelhead, should it occur, will be a consequence of straying by naturally produced fish. Release sites are prioritized for key spawning and rearing areas downstream of significant passage barriers or unscreened surface water diversions.

The first steelhead smolt releases occurred in 2007. These releases were made in anticipation of the new surface intake and collection facilities becoming operational in the spring of 2009. Table 9-6 shows proposed release numbers and locations.

Downstream migrants will be collected and marked before release below the hydropower complex so they can be readily distinguished from unmarked out-of-subbasin strays. Returning adults from the outplants will be specifically identified as upper subbasin origin fish. Adults originating from upper Deschutes habitats will also be differentiated from other in-subbasin or out-of-subbasin stocks through the use of unique fin-clips, PIT tags, or other tags.

A comprehensive monitoring and evaluation plan will be implemented to assess the success of reintroduction and provide the critical information needed to make adaptive management changes.

Crooked River Population

The following strategy and action are designed to restore natural production in the Crooked River population.

Strategy: Restore natural production to blocked areas above Pelton-Round Butte Complex.

Management action

1. Develop and implement a comprehensive plan for the reintroduction of steelhead into the upper Deschutes River subbasin above the Pelton-Round Butte Complex.

   Hatchery production will play a crucial role during the initial phases of reintroduction. The hatchery will operate with dual objectives: (1) produce fish for harvest mitigation and (2) produce fish to achieve conservation objectives. Under the conservation objectives, (OAR 635-007-0545(11)), goals associated with reintroduction would aim to meet objectives for supplementation and restoration to areas upstream of the complex.

   Round Butte Hatchery stock steelhead will be used for initial steelhead releases due to their availability and to concerns with impacts of collecting native stock steelhead. Native stock steelhead will be used once it has been determined that passage efficiencies through the complex are suitable. A genetic assessment has been initiated to characterize Deschutes River steelhead and redband trout populations. Results from this work will be used to help identify appropriate broodstock for reintroduction. This approach, including a reduction of hatchery releases as naturally-produced fish return, should lead to an adapted and productive natural steelhead stock.

   Steelhead fry or smolt releases will provide the primary means to re-establish adult returns to historical habitats during Phase 1 of reintroduction. Initial efforts to reintroduce steelhead will focus on productive habitats in McKay and Ochoco creeks and the mainstem Crooked River between River Mile 51 and River Mile 56. McKay Creek contains some of the better steelhead habitat in the lower Crooked subbasin (i.e., below

Bowman and Ochoco Dams). Release sites are prioritized for key spawning and rearing areas.

Under the present schedule, the first steelhead fry and smolt releases occurred in 2008 and 2009 respectively. These releases were made in anticipation of the new surface intake and collection and handling facilities going operational in the spring of 2009. Table 9-6 shows proposed release numbers and locations.

Downstream migrants will be collected and marked before release into the Deschutes River below the hydropower complex so they can be readily distinguished from unmarked out-of-subbasin strays. Returning adults from the outplants will be specifically identified as upper subbasin origin fish. Adults originating from upper Deschutes habitats will also be differentiated from other in-subbasin or out-of-subbasin stocks through the use of unique fin-clips, PIT tags, or other tags.

A comprehensive monitoring and evaluation plan will be implemented to assess the success of reintroduction and provide the critical information needed to make adaptive management changes.

Table 9-6. Initial estimates of annual releases of summer steelhead to occur within specific areas of the drainage basin upstream of PRBC as the reintroduction effort moves forward. Parental origin (brood) is identified as being Hatchery (H), Mixed (M), or Natural (N; this category includes steelhead parents that are the first-generation, hatchery-reared offspring of natural-origin fish).

Species	Phase of reintroduction	Stream area	Fry		Smolts	
			Brood	Number	Brood	Number
Summer steelhead	Phase 1	Deschutes R.	---	0[a]	---	0[a]
		Whychus Cr.	H	286,000[b]	H	5,000[b]
		Crooked R. system	H	288,000 – 708,000	H	7,500[c]
		All	***H***	***574,000 – 994,000***	***H***	***12,500***
	Phase 2	Deschutes R.	---	0[a]	---	0[a]
		Whychus Cr.	N, M, H	100,000-596,000[d]	W	7,700[d] (one generation)
		Crooked R. system	N, M, H	222,000-1,417,000[d]	W	13,000[d] (one generation)
		All	***N, M, H***	***322,000 - 2,013,000***	***W***	***20,700***

[a] There will be no releases of steelhead directly into the Deschutes R., nor into the Metolius R. system. Habitat in these areas is believed to be better suited to resident than anadromous rainbow trout production (Cramer and Beamesderfer 2006), and colonization of this habitat by steelhead, should it occur, will be a consequence of straying by naturally-produced fish.

[b] Initial annual releases into Whychus Cr. will be intended to supply enough marked smolts (both naturally-produced and hatchery produced) to test fish passage effectiveness downstream through LBC and into the SWW fish collection facility. The releases of fry assume 10 percent of the smolts naturally produced in the stream will be trapped and reach the head of the reservoir bearing detectible marks, and have been increased by 20 percent above the minimum number estimated to be needed for adequate statistical precision in the fish passage tests (238,000). Initial fry releases will also test fish performance in the habitat above PRBC and produce the first generation of adult steelhead to have reared as juveniles in that habitat for about 40 years. Numbers of fry to be released assume smolt production only in suitable habitat below the TSID diversion dam and not above that dam.

[c] Initial annual releases into the Crooked R. system below Prineville will be intended to supply enough marked hatchery smolts to test fish passage effectiveness downstream, and to provide naturally produced smolts that can be marked and pooled with those from Whychus Cr. to potentially make fish passage tests based on naturally-produced smolts more robust. The releases of fry will also be intended to help test fish performance in the habitat above PRBC and to produce returning adults that reared as juveniles in that habitat. As currently envisioned, the scope of steelhead fry releases during Phase 1 will be relatively limited.

[d] Annual releases during Phase 2 will supplement natural fish production associated with returns of adult steelhead that reared as juveniles above PRBC. Releases of fry will initially be of a magnitude estimated to be sufficient by themselves to produce about 50 percent of the maximum number of smolts, including that in areas of Whychus Cr. above the TSID diversion dam, and will diminish through time (note: the percentage will be reduced very early in Phase 2 if the number of returning adults exceeds expectations and there is a potential that fry outplants might otherwise overwhelm the offspring of these adults). There may be exceptions to this basic pattern in the Crooked R. system, however. Actual annual releases of fry will depend on broodstock availability and, in the Crooked R. system early in Phase 2, anticipated post-release environmental conditions. Hatchery produced smolts derived from disease-screened natural-origin parents collected below PRBC will also be released into these areas for a 5-year period, if available, in numbers equivalent to 50 percent of maximum natural smolt production, so that adults returning from the releases can also begin to supplement the developing natural runs. Hatchery support of the natural runs will diminish through time and end as soon as the runs can sustain themselves. Barring unforeseen circumstances, it will not continue for more than three fish generations in a given subbasin before the fish are given an opportunity to sustain themselves without artificial support.

John Day Populations (Lower Mainstem, North Fork, Middle Fork, South Fork, Upper Mainstem)

The following strategy and action address threats to natural spawning steelhead populations in the John Day subbasin from straying hatchery steelhead from outside the subbasin.

Strategy: Reduce uncertainty in abundance and proportion of stray hatchery fish that spawn naturally.

Management action

1. Increase efforts to monitor incidence of hatchery fish on spawning grounds through additional stream surveys and other methods.

   There are currently two types of surveys conducted during steelhead spawning times, index counts and Environmental Monitoring and Assessment Protocol (EMAP) surveys. Index counts are done once and EMAP surveys done at least three times during the spawning time period. Of the two types of surveys conducted, the EMAP surveys provide the best opportunity to document stray hatchery steelhead. However, currently the 50 EMAP surveys are done at the subbasin scale. Better information would be gathered if more surveys were done at the population scale. Additional methods such as kelt trapping could also be used. This is a consensus recommendation.

The HSRG recommendations are entirely consistent with the proposed actions for all five John Day River populations.

Umatilla River Population

Although hatcheries were not identified as a key threat to the Umatilla River steelhead population, several management actions are proposed to reduce the risk of out-of-subbasin strays and the risks associated with ongoing hatchery programs in the subbasin.

Strategy 1: Reduce abundance and proportion of out-of-subbasin strays spawning naturally.

Management action

1. Uniquely mark Umatilla Hatchery steelhead and remove other hatchery strays at Three Mile Falls Dam to limit out-of-subbasin strays from reaching the spawning grounds.

   In recent years, out-of-DPS strays comprised a mean of 4.8% of steelhead returning to TMFD. These strays mostly originate from lower Snake River hatchery programs. Uniquely marking Umatilla hatchery steelhead would allow removal of out-of-subbasin stray steelhead at TMFD and eliminate the potential for outbreeding depression and impaired diversity. Major logistical constraints include the additional costs of applying an identification mark to 150,000 steelhead smolts. In addition, 100% of fish escaping past TMFD would need to be trapped and identified, as opposed to the current practice of enumerating a portion of the run through video analysis of adults swimming past the viewing window in the adult ladder. Due primarily to concerns related to additional stress of handling all fish at TMFD, this is a non-consensus recommendation.

Strategy 2: Re-establish natural production into historically utilized habitats.

Management action

1. Re-establish natural production in Little Butter and Butter creeks (MaSAs) and some minor spawning areas by outplanting adults and/or releasing juveniles into the tributaries after habitat, flow and passage is restored to a level that will support steelhead production.

   The loss of occupancy in the Butter Creek system was identified as a significant spatial structure gap. Re-establishing natural production in these historically occupied areas will lower the risk levels by expanding spatial extent/range and decreasing gaps between spawning areas. Re-establishing spatial extent and reducing gaps will reduce vulnerability to local catastrophes, enhance historical life history diversity, and enhance gene flow and the ability to recolonize extirpated areas. Any effort to re-establish production in formerly occupied areas should follow habitat restoration actions to address passage constraints, loss of instream flow, and degraded water quality and habitat. Once habitat, flow and passage are restored to the point that tributaries can again provide spawning and rearing habitat for steelhead, reintroduction can proceed. The benefits extend to the population in re-establishing the population across its historical range and decreasing gaps between spawning areas. The timeline for this action is dependent on the extent and rate of recovery of degraded habitat and successful removal or alteration of passage impediments. This is a consensus recommendation.

Strategy 3: Reduce the genetic influence of hatchery fish in hatchery broodstock.

Management action

1. Eliminate the use of hatchery produced adults in the broodstock to reduce potential for divergence in genetic and phenotypic traits between hatchery and natural-origin steelhead.

   Sufficient natural-origin adults have been available in all years to meet broodstock needs; however, hatchery fish are used in some years. Implementing this action will eliminate the use of adults that have undergone domestication selection and reduce genetic and phenotypic divergence from the natural-origin stock. A potential downside of this management action would be further reducing the abundance of natural-origin steelhead spawners and increasing abundance of hatchery steelhead on the spawning grounds. This is a non-consensus recommendation.

Strategy 4: Reduce interactions between residual hatchery steelhead and natural steelhead to limit competition with and potential predation on natural steelhead juveniles.

Management action

1. Conduct volitional releases steelhead smolts and remove the fish that do not migrate.

   Reducing interactions between hatchery and natural steelhead reduces the threat that natural juveniles rearing in the Umatilla River will experience reduced survival or

mortality from competition with hatchery smolts. To further reduce competition between natural and hatchery juveniles, smolts remaining in the acclimation ponds after the volitional release period could to retained rather than forced into the Umatilla River. This technique has been used in other subbasins (e.g., Tucannon, Grande Ronde, Imnaha), usually according to guidelines on the sex ratio and numbers of smolts remaining in the acclimation pond. Research on the Tucannon River, Washington demonstrates that juveniles remaining in acclimation ponds after volitional release periods are predominantly male and few exhibit smolt characteristics and that retaining these fish reduced the abundance of residuals in the river (Viola and Schuck 1995). The management action could be implemented at the two existing acclimation facilities on the Umatilla River. This is a non-consensus recommendation due to logistical concerns expressed by Facility operators.

Strategy 5: Reduce potential negative ecological interactions between coho salmon and natural steelhead.

Management action

1. Reduce the number of hatchery coho released in the Umatilla River and relocate releases downstream to areas not currently important for steelhead production.

   Currently, approximately 1.5 million coho salmon smolts are released into the Umatilla River annually from the Pendleton Acclimation Facility. These coho salmon smolts have the potential to compete with juvenile steelhead for prey resources or space. This competition may reduce survival or result in direct mortality of steelhead juveniles, affecting productivity and abundance. Several steps could be taken to reduce potential interactions between coho salmon and steelhead smolts. Actions range from eliminating the Umatilla coho salmon program to changing the numbers, locations or methods of release of coho salmon. Because steelhead rearing habitat occurs downstream of McKay Creek where the colder water released from McKay Reservoir enters the Umatilla River, one potential solution would be to release coho salmon downstream of steelhead rearing habitat in the lower Umatilla River. Pendleton is the most downstream acclimation facility, so implementing this action would require either direct stream releases of coho salmon or construction of another acclimation facility on the lower Umatilla River. If implemented, the action would affect rearing habitat in the lower Umatilla River between Pendleton, where coho salmon are currently released, and the new release location. The largest logistical constraint would be locating and funding a new acclimation facility on the lower Umatilla River. No logistical constraints would exist for directly releasing coho salmon into the lower Umatilla River. There was consensus on reducing the number of coho released annually to at least 1 million. However, changing location of release was not a consensus recommendation.

The HSRG had no recommendations for the Umatilla population and related hatchery programs.

Walla Walla River Population

Several hatchery management actions and proposals to manage and reduce hatchery risks to the Walla Walla summer steelhead population were developed and are presented below. Consensus could not be reached to identify a preferred alternative.

Strategy: Reduce the abundance and proportion of non-local-origin hatchery strays spawning naturally.

Management actions

1. Eliminate adult hatchery strays above Nursery Bridge Dam by resuming trapping operations and removing hatchery fish.

   Removing hatchery strays above NBD would eliminate the threats and resulting diversity risk caused by introgression of hatchery steelhead into the natural population. Sorting and removing hatchery produced adults at NBD would greatly reduce or eliminate these threats. However, resumption of trapping activities would cause handling stress on natural-origin adults and may result in a small amount of mortality. This is a non-consensus recommendation due to concerns of handling natural-origin fish and associated risks.

2. Alter the release strategy of Lyons Ferry Hatchery smolts released into the lower Walla Walla River from direct stream to acclimated releases and implement trap and removal near the acclimation site.

   Changing the release strategy of smolts in the lower Walla Walla River from a direct stream to an acclimated release has the potential to reduce wandering of returning hatchery adults into the upper Walla Walla River. If lower stray rates were realized, it would reduce risks. The action would require construction of an acclimation facility on the lower Walla Walla River to hold smolts in natural stream water before release. While the action would be implemented on the lower Walla Walla River, effects could be realized throughout the subbasin. There was considerable concern expressed about the costs of this action as well as the logistics of separating natural-origin and hatchery-origin fish in the adult trapping component. This is a non-consensus recommendation.

3. Develop local broodstock to replace Lyons Ferry stock for use in the current harvest augmentation program.

   Developing local broodstock for use in the current program would reduce the risks to the natural population because the hatchery fish that stray and spawn naturally would have similar genetic characteristics to the natural fish. However, the initial stages of broodstock development would require mining natural-origin fish from the natural population reducing the effective number of spawners. This is a non-consensus recommendation due to concerns of removing natural-origin fish to initiate the broodstock.

4. Develop local broodstock to replace Lyons Ferry stock and initiate a natural production supplementation program.

   Develop local broodstock from natural-origin fish collected at Nursery Bridge Dam. Move the smolt release location upriver someplace near the Oregon-Washington state line. Allow hatchery fish to intentionally escape into natural production areas and spawn naturally. This action would potentially reduce the genetic risks because hatchery fish would have similar genetic characteristics as natural fish. However, hatchery fish will comprise a much larger proportion of natural spawners than under current scenarios. Considerable concern was expressed about this action due to lack of demonstrated success of supplementation, the number of studies demonstrating negative viability affects of hatchery fish, and the fact that current abundance and productivity are very near viable criteria. This is a non-consensus recommendation.

5. Maintain current Lyons Ferry harvest augmentation program and initiate endemic local broodstock supplementation program in upper mainstem Walla Walla River and Mill Creek.

   This proposal maintains the 100,000 Lyons Ferry direct stream smolt release into the mainstem Walla Walla River. In addition, local broodstock would be collected at Nursery Bridge to initiate a supplementation program. An initial target of 35 pairs would be collected to produce 100,000 smolts annually. The smolt production would be split for release with 50,000 direct stream into Mill Creek and 50,000 direct stream into the upper Walla Walla River near the North Fork. This action would result in an increased proportion of hatchery fish in the natural spawners because of the additional hatchery spawners produced from the endemic supplementation program. The overall benefits and risks to viability are dependent on a number of performance factors for which the outcomes are uncertain. This is a non-consensus recommendation due to concerns of increased hatchery proportions and lack of demonstrated success of supplementation.

Some elements of the HSRG recommendations are consistent with the proposed management actions and some are inconsistent. The HSRG recommended to "Eliminate the annual importation and release of out-of-basin fish and develop within basin adult collection to promote locally adapted hatchery broodstock." Management actions numbers three and four are consistent with this recommendation. The HSRG also recommended "Under any scenario, facilities to acclimate and release juveniles and recapture returning adults will need to be developed." Management actions numbers one and two are consistent with this HSRG recommendation.

Development and implementation of a preferred alternative will require co-manager agreements developed through the Columbia Basin decision processes, such as US v. Oregon, Columbia Basin Fish and Wildlife Program, the Lower Snake River Compensation Plan, as well as, state and tribal planning processes.

9.8 Predation and Competition Strategies and Actions

Predation strategies and actions are discussed below. No actions are currently proposed to address potential competition related threats.

9.8.1 Predation Strategies and Actions

Predation by pinnipeds, birds, and piscivorous fish in the mainstem Columbia River has become a contributing factor affecting the viability of the Mid-Columbia River steelhead DPS. We present the following strategies and management actions to address predation concerns. These include actions from October 2007 Proposed Action for the Federal Columbia River Power System (NOAA Fisheries 2007a), as well as, additional actions being considered that would contribute to improving survival. Presentation of the BiOp proposed actions in no way implies endorsement of the adequacy of the actions for recovery.

Predation by Pinnipeds
The following actions will reduce predation by Pacific harbor seals, Steller sea lions, and California sea lions on salmon and steelhead in the lower Columbia River.

Strategy: Reduce the seasonal abundance of pinnipeds at Bonneville Dam.

Management actions
1. Continue with hazing program at Bonneville Dam to reduce pinniped seasonal abundance and predation near the dam.
2. Provide and improve sea lion excluder devices (SLEDs) to prevent pinnipeds from entering fishways.
3. Maintain acoustic devices to move pinnipeds away from fishway entrances, project facilities, and navigation locks.
4. Pursue authorization under Section 120 of the MMPA to remove problem California sea lions.

Predation by Avian Predators
The following actions are proposed to reduce predation by native bird species, such as Caspian terns and double-crested cormorants, in the Columbia River estuary.

Strategy 1: Relocate Caspian tern colonies in the Columbia River away from corridors that increase the vulnerability of juvenile salmon and steelhead out-migrants.

Management actions (actions in addition to those in the FCRPS proposed actions are presented in italics)
1. Maintain habitat conditions on Rice Island unsuitable or undesirable for nesting terns.
2. Reduce nesting habitat on East Sand Island and relocate most of the Caspian tern colony to areas outside of the Columbia River Subbasin.
3. Develop and implement an avian management plan to address predation from the Caspian tern colony on Crescent Island.
4. Modify dredge spoil disposal practices to avoid creating habitat suitable for Caspian tern nesting.

5. Modify hydropower operations to provide sufficient river flow to decrease travel times and water clarity for migrating juvenile salmonids.
6. Implement rearing practices that would enhance predator avoidance behavior in hatchery salmonids.

Strategy 2: Begin to address predation by double-crested cormorants in the Columbia River estuary and mid-Columbia.

Management actions
1. Continue to conduct research on predation impacts of double-crested cormorants on migrating juvenile salmonids, bioenergetics modeling, and habitat/population management strategies.
2. Develop an avian management plan to address predation by double-crested cormorant colonies on East Sand Island and Foundation Island (mid-Columbia).

Strategy 3: Deny predation opportunities to other avian predators such as California gulls.

Management action
1. Implement and improve deterrent devices and activities (e.g. bird wire, water cannons, hazing) at dams to keep avian predators away from bypass outfalls and other areas of juvenile salmonid concentration.

Predation by Piscivorous Fishes
The following actions are proposed to reduce predation by northern pikeminnow and a wide variety of introduced species (such as walleye, smallmouth bass, and channel catfish) that prey on juvenile salmonids in the Columbia River.

Strategy 1: Continue to implement the NPMP with exploitation rates at 10-20% to maintain reduced predation rates on juvenile salmonids.

Management actions (actions in addition to those in the FCRPS proposed actions are presented in italics)
1. Implement the sport-reward program with increased rewards similar to the enhanced reward structure in 2001 and 2004-2006.
2. Evaluate the effectiveness and relative efficiency of a hook-and-line fishery at select dams on the mainstem Columbia to remove northern pikeminnow in areas inaccessible to sport-reward anglers.

Strategy 2: Begin to address the management of non-indigenous piscivores as a means of reducing predation on juvenile salmonids.

Management actions (actions in addition to those in the FCRPS proposed actions are presented in italics)
1. Organize a workshop to review and evaluate predation by non-indigenous species (consumption rates and abundance), and develop strategies to reduce predation.
2. Implement transplant or removal programs in select areas.

3. Adopt regulatory changes that encourage harvest of target species.
4. Implement hydro-operation changes to reduce recruitment of non-indigenous predators.

9.8.2 Competition Strategies and Actions

As discussed in Section 8, steelhead abundance and capacity in the Deschutes Westside population may be significantly reduced by competition with resident rainbow trout. However, no management actions are proposed because a reduction in steelhead capacity due to resident trout abundance is considered a potential natural interaction effect. If, in the future, additional studies confirm this reduction in capacity in waters with abundant larger rainbow trout, then the abundance criteria for the Deschutes River Westside steelhead should be reevaluated.

Section 10 Management Action Effectiveness

This section presents an analysis of the effects of actions on the performance of Oregon populations in the Mid-Columbia River steelhead DPS. Projected levels of effectiveness in improving abundance and productivity for the actions described in the previous section are analyzed using modeling tools. Results are expressed as changes to population abundance and productivity parameters, as they were defined by the ICTRT for baseline conditions for each population (Section 6). The analysis was performed in sequential steps, first by projecting outcomes for tributary actions alone, then sequentially adding in hatchery fish genetic effects, then types of out-of-subbasin actions, and finally actions to manage stray hatchery fish. Results of each of these steps provide a means of comparing relative benefits of the proposed actions and assessing the overall benefits of the combined actions. We recognize that there is uncertainty associated with many of the input parameters and model assumptions used in our assessment of management action effectiveness. The models we used do not have the capability to characterize statistical certainty. We examined combinations of different temporal response periods, alternative tributary habitat action implementation priority scenarios, and alternative ocean conditions in an attempt to characterize the range of potential population responses to the management actions. The results of our effectiveness analyses should not be viewed as predicted responses, rather as ranges of potential outcomes. We were not able to assess spatial structure/ diversity effectiveness in a quantitive manner. Therefore, we assess the spatial structure/ diversity effectiveness by describing how the specific actions which target gaps will improve status.

The section is presented in four parts:

1. Methods.
2. Results of the abundance/productivity analysis of tributary habitat actions.
3. Results of the abundance/productivity analysis of all other actions by integrating effectiveness across actions, including tributary actions.
4. Results of the spatial structure/diversity effectiveness.

10.1 Methods

We performed our analysis of action effectiveness for abundance and productivity using two modeling platforms that have been widely applied in the Columbia basin: EDT and All-H Analyzer (AHA). These modeling approaches are discussed below. Action effectiveness for spatial structure and diversity was assessed qualitatively by describing the specific actions and how the actions are expected to address the spatial structure/diversity impairments.

10.1.1 Approach

EDT and AHA address different life stages in the life cycle and thus the different limiting factors that affect salmonid population performance (Figure 10-1). We incorporated several refinements to the modeling procedures for each platform as they are usually employed in the region to improve application for our objectives. For EDT, we formulated an auxiliary tool for defining action effectiveness to better ensure that we considered the distinct elements of effectiveness

consistently between actions and subbasins, and we incorporated an implementation timeframe element. For AHA, we disaggregated the life cycle into more segments than used in the standard AHA in order to completely incorporate the effects of habitat conditions in the juvenile life stages following emigration from the subbasin through the adult life stages, until return to the subbasin. We also formulated a module for AHA to provide an efficient way of processing the large number of action combinations—both in tributaries and the mainstem Columbia—of interest to this analysis. In addition, we modified the default settings in AHA for genetic fitness to produce results that appear to be more consistent with how the populations of interest are currently performing.

We used the modeling results to assess relative changes in population performance due to management actions compared to performance under a baseline set of conditions (both within and out of subbasin). We then applied these relative changes to the baseline performance measures as derived empirically for each population by the ICTRT. In applying the results in this way, we assume that each modeling platform provides a useful and appropriate assessment of how actions can be expected to affect performance relative to the baseline. We avoid the question of how well EDT output parameters represent actual performance levels if measured accurately over a sufficient period of time (e.g., as addressed by Rawding 2004[2]).

The EDT model was used to analyze the potential benefits of tributary habitat actions. The model is designed to estimate salmonid population performance based on characteristics of the aquatic habitat (Mobrand et al. 1997; Blair et al. *in press*). While it considers conditions at all life stages—producing population parameters for the entire life cycle—it was originally built to address factors that affect freshwater survival. In the Columbia basin, it has been used to focus on habitat conditions within subbasins, being applied in nearly every subbasin that currently supports anadromous salmonids. It was the principal modeling tool used to formulate many of the recently completed subbasin plans, including those that support the populations in the Mid-Columbia River steelhead DPS. The EDT analyses for these subbasins provide one part of the limiting factors assessment of subbasin habitat conditions described in Section 8 of this plan. The stream reach and habitat characterizations used in those analyses were applied as part of the baseline conditions for the analysis presented herein.[3]

The EDT model is particularly well suited for analyzing effects of habitat actions on salmonid population performance. As part of its setup, it requires characterizations of both historical and existing habitat conditions for all stream reaches used by the population of interest (see Lichatowich et al. 1995). This provides a simple, logical framework for considering the effectiveness of future habitat actions. The Scenario Builder tool, one of the suite of EDT modeling tools, is then used to explicitly define the extent that an action might be expected to

[2] / Rawding (2004) compared EDT model output with observed data for several salmon and steelhead populations in the lower Columbia River. He concluded that spawner-recruit performance results were comparable between observed data and EDT outputs when recruits were measured as smolts (EDT does not incorporate variation in marine survival).

[3] / All of the data inputs completed as part of the subbasin planning process were unchanged for the analysis reported herein with two exceptions. It was discovered that the population age structure for Fifteenmile winter steelhead was incorrect, requiring an update to this input. Secondly, the spawning distributions specified for the Deschutes Eastside and Westside populations were not consistent with those defined by the ODFW steelhead distribution database and ICTRT. These inputs were updated to reflect ODFW and ICTRT information.

move reach-specific habitat characteristics back toward the pre-development state (Thompson et al. *in press*). Scenario Builder also allows for defining actions that represent future watershed development, as would occur over time with human population growth. In this case, the tool can be used to identify the extent that reach characteristics move further away from the pre-development state and toward a fully developed one. This aspect of the tool is used extensively as part of recovery planning in areas where human population growth is rapidly increasing, such as in the Puget Sound region (Thompson et al. *in press*), but it was not applied here. Growth is expected to be relatively slow in the subbasins of interest here and patterns of future development are not well defined. Actions intended to give protection against further habitat loss can be analyzed with Scenario Builder when habitat loss actions are also defined.

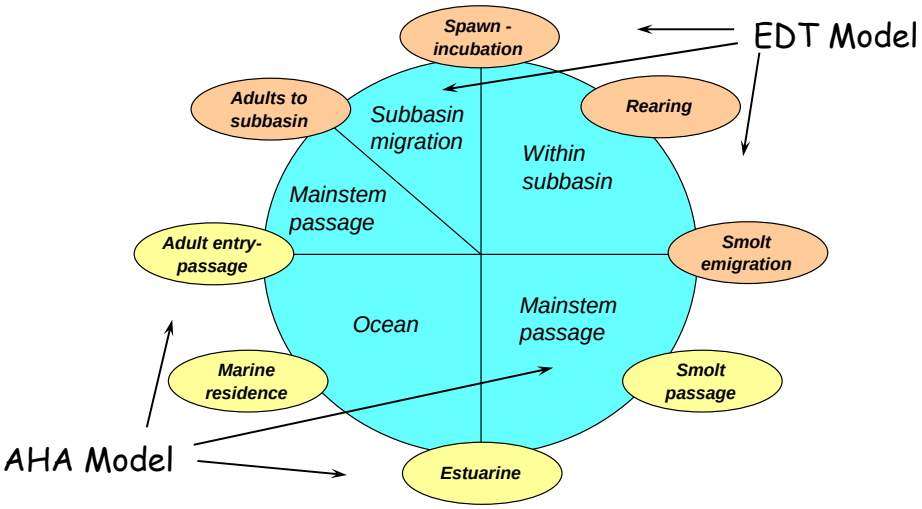


Figure 10-1. Use of EDT and AHA modeling platforms for different segments of steelhead life cycle. The EDT model covers the life stages from adults to subbasin through smolt emigration and AHA covers smolt passage through adult entry.

Four scenarios were modeled using the EDT model, reflecting two priorities for where actions would be implemented at two future times:

1. High priority action areas only at 25 years in the future;
2. High priority action areas only at 100 years in the future;
3. All priority action areas at 25 years in the future; and
4. All priority action areas at 100 years in the future.

Each scenario for each population consisted of a large number of diverse actions aimed at improving habitat conditions for the affected population (see Section 9). In addition to these four scenarios, the Deschutes Westside population was modeled with and without passage at the Pelton-Round Butte Complex to illustrate the added benefit of passage and restoration of natural production in the blocked areas..

The standard output from EDT consists of Beverton-Holt population parameters for smolt yield (leaving subbasin during smolt migration window) and spawners (virgin spawners successfully

spawning). The parameters are productivity (progeny per parent at low density), carrying capacity, and equilibrium abundance (i.e., average). Repeat steelhead spawners are not computed in the model, but repeat spawning is known to be very small (<5%; Busby et al. 1996) for Mid-Columbia steelhead. Parameter values produced for each scenario were used to compute the percent change in the parameter compared to the baseline. We used these relative changes to characterize the potential benefits to population performance corresponding to each scenario. Another EDT output is referred to as life history diversity and is a measure of the distribution of life cycle pathways through time and space determined to be successfully completed within the modeled environment. The model creates a multitude of diverse time-space pathways (or trajectories) through the environment consistent with the species' known life history patterns (incorporating seasonal movement patterns, rates of movement, and age structure), computing life cycle productivity and capacity parameter values for each pathway under each scenario. The percentage of pathways that are able to be completed successfully (i.e., having a productivity ≥1) of the entire set of modeled pathways is reported in the output as the % life history diversity. A value of 100% means that all modeled pathways would be expected to support completed life histories over the entire life cycle. In contrast, for example, a value of 20% would mean that only 20% of the pathways would support successful life histories—indicating that 80% of the pathways encountered such poor conditions for survival at some times or places (or were blocked by barriers) that life history condition was not possible. Typically, modeling of the undeveloped environment (historical condition) produces values for this metric at or near 100%. Modeling of severely degraded environments yields values much reduced—in severe cases <20% of the pathways might be successful. A large reduction in this metric compared to the undeveloped state usually means that significant portions of habitat no longer support sustainable production and, in the case of steelhead, older aged life history patterns have become less productive. The underlying concept of the metric is that it will reflect a real change in diversity of life history pathways relative to the undeveloped state that can be supported under the habitat conditions being modeled. Applying it to action analysis, if the current condition scenario yields a value of 20% for this metric, then how much does the metric change under a prospective action scenario? In this case, a large increase in the metric associated with an action scenario would mean that a significant expansion has occurred in life history distribution with improved habitat.

We report the results for this life history diversity metric to reflect only one aspect of how life history diversity would be expected to change due to an action set. The ICTRT is concerned about life history diversity at a larger scale than represented in the EDT measure, where patterns of distribution, movement, and age structure are considered. The EDT metric is not an equivalent measure, even though it reflects all of these higher scale patterns to some extent. We are currently exploring how information from the EDT results can be summarized to reflect changes in these patterns at the ICTRT criteria scale as a result of tributary actions.

The relative restoration benefit is determined by comparing current conditions to restored conditions resulting from implementation of proposed tributary habitat actions. We assessed restoration benefit for two scenarios for each population: 1) priority 1 actions only after 100 years; and 2) priorities 1 and 2 actions after 100 years.

The relative restoration benefit was determined based on the ranking of the amount of change in the consideration of all three previously decribed population performance measures (abundance,

productivity, diversity). All reaches or geographic areas were assigned a rank based on the change for each performance measure. The reach with the largest change was assigned higher values unless there was a tie. The three performance measure ranks for each reach were then summed and a simple average was computed. The reaches were then re-ranked so that the reach with the lowest average was giving a value of 1 (highest restoration benefit); all other reaches were assigned higher values.

Following the completion of the integrated ranking procedure, reaches were grouped and placed into four categories including: high, moderate, low, or very low, restoration benefit. The very low restoration benefit category includes reaches where zero restoration benefit is achieved. Results of the restoration benefit analyses are presented in maps in this section, as well as, in tables in Appendix H.

The AHA model was used to link the analyses of tributary habitat actions to prospective recovery actions involving hatchery fish and the mainstem Columbia River and to explore a few simple alternative ocean assumptions. The output from EDT, expressed in terms of Beverton-Holt population parameters, was an input to the AHA model. The AHA model was developed to give managers a tool for examining different ways of balancing habitat restoration, hatchery practices, harvest, and hydroelectric facilities operation (Mobrand – Jones & Stokes Associates 2005). It is particularly adapted to addressing the effects of hatchery operations, having been created by the Hatchery Scientific Review Group[4] to consider genetic interactions between hatchery and natural stocks. Model features incorporate theoretical concepts about these interactions based on Ford (2002) and Lynch and O'Hely (2001), and as further discussed by Mobrand et al. (2005).

Linking the two models provides a way of assessing benefits measured at the end of the life cycle for a wide range of potential actions, regardless of what life stage an action affects. The AHA platform integrates the effects of various types of actions over the full life cycle (Figure 10-2A). The output from AHA, also expressed as Beverton-Holt population parameters, represents the expectation for population performance when all actions are integrated together. Here, these parameters were then converted to the percent change in each parameter value compared to baseline conditions and multiplied by the ICTRT's baseline population measures to compute expected ICTRT-equivalent parameter values reflecting the effects of all actions (Figure 10-2B). The two parameters of interest here are population intrinsic productivity (recruits per spawner at low population density) and equilibrium spawner abundance. These parameters, whether estimated by EDT/AHA modeling or empirically as done by the ICTRT, are identical in meaning though they can differ in actual value for the same population due simply to different ways of estimation. Therefore, a conversion to an "ICTRT parameter equivalent" was necessary to allow for a direct comparison of output to the ICTRT baseline values. It was concluded that this simple multiplication procedure is the appropriate mathematical conversion to compute the change in ICTRT parameter values from EDT/AHA output.

[4] / The Hatchery Scientific Review Group is an independent scientific panel established and funded by Congress to provide an autonomous and credible evaluation of hatchery reform as part of the Hatchery Reform Project. The objective of the HSRG is to assemble, organize, and apply the best available scientific information and to provide guidance to the policymakers and technical staff who are implementing hatchery reform. The project is being applied in most areas of the Pacific Northwest, including within the Columbia Basin.

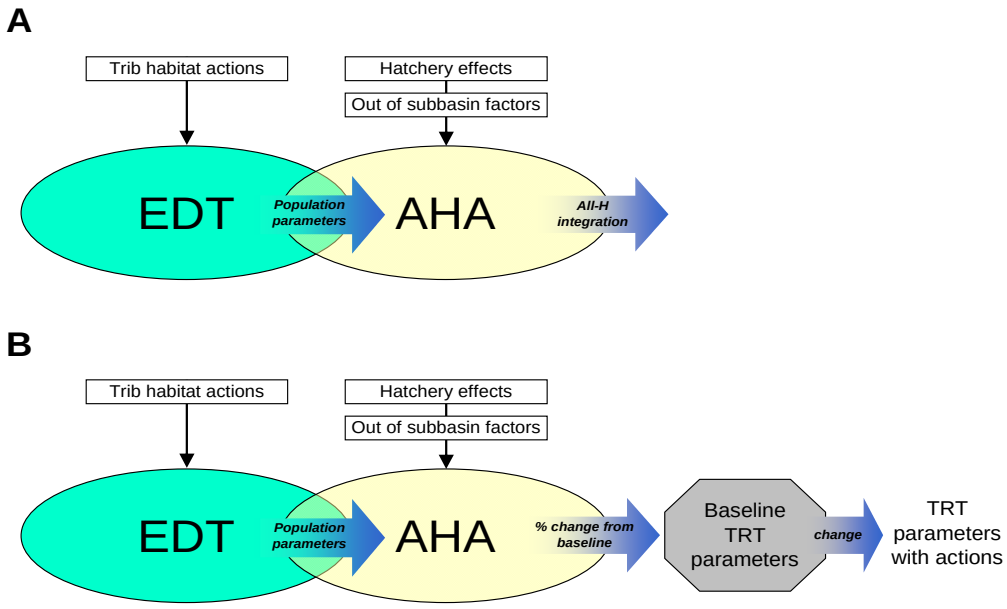


Figure 10-2. Action integration components.

The AHA model is principally used in the region to help evaluate hatchery programs and makes broad comparisons involving other strategy types. In the analysis presented herein, a strong focus is placed on integrating actions that not only involve hatcheries and out-of-subbasin actions, but detailed subbasin habitat restoration plans. The standard AHA model uses a simplified approach in integrating across such a range of actions by treating the effects of out-of-subbasin actions on population productivity and capacity as multipliers on parameter values produced by EDT, hence it assumes simple multiplicative effects. In doing so, effects of performance parameters for the final life stages (pre-spawning and spawning) are not fully incorporated, which can bias spawner estimates from the model high.[5] Therefore, the AHA platform was modified by first disaggregating output into life stage segments as described in Beverton and Holt (1957) and Mousalli and Hilborn (1986), then linking AHA inputs to the appropriate segment and re-computing end of spawning population parameters by reaggregating across the full life cycle (Mobrand et al. 1997). This modification provided a way of producing essentially unbiased parameter estimates.[6]

[5] / All life stages affect the performance of a salmonid population when measured at the end of the life cycle. Both habitat quality and quantity can affect fish performance during each life stage, and therefore, also affect population performance measured at the completion of the life cycle (end of spawning). Hence, benefits of actions affecting intermediate life stages, such as outmigrating smolts or returning adults within the mainstem Columbia River, do not proportionally translate into performance benefits when measured at the end of spawning in the subbasins. This is clearly evident in examining the Beverton-Holt function disaggregated into life stage segments.

[6] / The AHA model is to be updated formally to address this computational need (Lars Mobrand, personal communication). The procedure used in our analysis involved the use of a supplemental EDT output called the Hits file, which contains detailed results for each life history trajectory. These results were disaggregated to life stage, then used to compute weighted average performance parameter values for each life stage. This step was necessary for just the baseline model run, giving an analytical reference that could then be used to compute final adult life stage values for each action scenario.

A set of scenarios was modeled using AHA representing baseline conditions, current conditions, and combinations of actions aimed at tributary habitat, mainstem Columbia River factors, and hatchery fish management. Baseline conditions represent average conditions for the migration years 1980 to 2001 which represents the time period that recruit-per-spawner data were used for the ICTRT viability assessments. Current conditions are intended to generally reflect recent years (2002 to 2006) measures implemented for mainstem Columbia hydrosystem predation, estuary, and harvest. The benefits of these actions are not represented in the baseline abundance and productivity estimates. Population parameter estimates derived by the ICTRT in Section 6 reflect baseline conditions. Prospective actions to be taken in the mainstem Columbia River and estuary that were modeled include:

- Predator management – aimed at reducing predation rates caused by avian and northern pikeminnow;
- Downstream juvenile passage improvements – measures to improve survival at each of the mainstem dams;
- Columbia estuary habitat improvements – measures to enhance habitat conditions within the Columbia estuary; and
- Harvest – regulatory measures to reduce or hold harvest impacts in the mainstem Columbia River to current levels.

Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, then adding in actions sequentially, each being added to the previous scenario. The effects of hatchery steelhead programs on genetic fitness—hence performance—of natural-origin fish were incorporated for each scenario using AHA.

Actions that would control the number of stray hatchery fish in subbasins where feasible were modeled as part of another set of scenarios. In this case, the full set of scenarios aimed at tributary habitat and mainstem factors was modeled with and without these actions.

The effects of potential changes in marine survival were also modeled with a few alternatives. All of the scenarios described above were modeled using an average marine survival rate corresponding to the average during both the baseline and current periods. We then modeled two more scenarios, which consisted of all actions combined, using marine survival rates set to +/- 25% of the average applied to the other scenarios. This range is consistent with how average marine survival appears to vary between periods of years for Mid-Columbia River steelhead.[7] These results are intended to reflect outcomes of implementing recovery actions under alternative possible future marine survival regimes that might either decline or improve compared to the baseline average.

As noted previously, we formulated a module for AHA that enabled us to efficiently analyze the various combinations of tributary and mainstem action scenarios, in conjunction with hatchery management actions.

[7] / Inter annual variability in marine survival can be incorporated into AHA but estimates of population parameters are then made in a way that represents the average marine survival over the years used in modeling. We simplified the analysis by just applying an average marine survival to represent the modeled outcome within a period of years.

Table 10-1 lists the various combinations of actions and effects that were modeled for each population using AHA.

Table 10-1. Combinations of actions and effects modeled for each steelhead population using the AHA model. See text for definitions of baseline and current. Action groups are listed in columns, corresponding to where they would be implemented. Hatchery effects are those associated with modeled changes in genetic fitness of natural-origin fish due to hatchery strays. Codes are: B – baseline condition, C – current condition, B/C – baseline/current condition (assumed to be the same for both), A – actions implemented.

Scenario	Tributary		Mainstem Columbia				Ocean
	Trib habitat	Hatch effects	Pred control	Hydro pass	Est habitat	Harv regs	Marine surv
Baseline	B/C	B/C	B	B	B	B	B/C
Current	B/C	B/C	C	C	C	C	B/C
Trib habitat actions	A	B/C	C	C	C	C	B/C
Mainstem actions	A	B/C	A	C	C	C	B/C
- add more	A	B/C	A	A	C	C	B/C
- add more	A	B/C	A	A	A	C	B/C
- add more	A	B/C	A	A	A	A	B/C
Hatch fish actions	A	A	A	A	A	A	B/C
Alter marine surv	A	A	A	A	A	A	+/- 25%

In addition to these scenarios, the Deschutes Westside population was modeled with and without passage at the Pelton-Round Butte Complex to illustrate the added benefit of providing passage and re-establishing natural production.

10.1.2 Tributary Habitat Effectiveness

Details of how action effectiveness was modeled are described below.

Non-Passage Actions
The EDT Scenario Builder tool is used to capture assumptions about the effectiveness of an action in altering attributes of habitat within a river system. EDT habitat characterizations consist of ratings of 46 environmental attributes (flow, sediment, temperature, etc.) that describe the conditions of each stream reach delineated within a river system (see Lestelle et al. 2004). The characterizations are meant to represent an average state of conditions within a time period, i.e., current period, pre-development period, or a future period corresponding to the outcome of one or more habitat actions.

The Scenario Builder can be inefficient and awkward to use with large numbers of actions, multiple watersheds, large numbers of stream reaches, and multiple time lags in evaluating action effects. This can result in inconsistencies in how actions are defined with respect to their effectiveness. To minimize potential inconsistencies, an auxiliary tool (Action Mapper) was formulated for this project to define effectiveness through a set of systematic steps for all actions. The tool—built in Excel—helped ensure that action effectiveness was being formulated

consistently across populations by providing more transparency in defining effectiveness assumptions and giving improved documentation.

A total of 93 distinct actions within eight strategy types were assembled from Section 9 into a library of actions for processing. (Aspects of some actions overlapped with others, which required some consideration in assigning effectiveness values to reduce redundancy and overestimation of action benefits.) The action library is listed in Table 10-2 showing which actions were applied in each of the five subbasins. Although we summarize the library at the subbasin scale, actions are actually applied at the individual population scale, as well as, all areas downstream of the population boundary in the subbasin that are used for rearing and migration.

The Action Mapper was used to derive the effectiveness values for all action-stream reach-attribute combinations applicable to the analysis, which were then loaded into the Scenario Builder for input into EDT. The derivation consisted of two parts:

1. Part 1 - Mapping the precise geographic distributions of stream reaches that would be affected by the actions within each population, and
2. Part 2 - Quantitatively defining the various elements used to compose action effectiveness in the analysis.

The steps associated with each part provided a consistent process for deriving effectiveness values for each action.

Table 10-2. Tributary habitat actions modeled in each subbasin.

Strategy and action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
1. Protect/conserve ecological processes					
Land acquisition/conservation	x	x	x	x	x
Protect rare functioning habitats	x	x	x		x
BMPs to conserve eco processes	x	x	x	x	x
Cooperative Agreements		x	x		
Special mgmt designations		x	x		
Increase wild-scenic status			x		
Protect access to key habitats			x		
Public lands protection				x	x
Waterway setbacks				x	x
Enforce floodplain regs				x	x
Natural Area Overlay Zone				x	x
Legislate priority areas				x	x
Outreach to users and managers			x		
2. Restore fish passage blocked/impaired by barriers					
Barrier removal	x	x	x	x	x
Add irrigation screening	x	x	x	x	x
Improve irrigation screening	x	x	x	x	x
Pelton Round Butte passage		x			
Reduce push up dams			x		
Fish ladder construction			x	x	x
Maintain passage facilities				x	x
3. Maintain and restore floodplain connectivity and function					
Reconnect floodplain	x	x	x		x
Reconnect side channels	x	x	x		x
Reintroduce beaver	x	x	x		
Manage beavers					x
Restore wet meadows			x		
Dike removal				x	x
4. Restore degraded and maintain properly functioning channel structure/complexity					
Restore natural channel form	x	x	x	x	x
Large wood enhancement	x	x	x	x	x
Add structure	x	x			
Stabilize streambanks	x	x	x	x	x
Build pool weirs				x	x
BMP bridge maintenance					x
LWD education					x
5. Restore riparian condition and LWD recruitment					
Restore riparian communities	x	x	x	x	x
Improve grazing practices	x	x	x	x	x
Eradicate invasive plants	x	x			
Fencing	x	x		x	x
Off-stream livestock watering	x	x			
Riparian plantings	x				
Increase riparian shading		x			
No cultivation buffer zones				x	x
Maintain RHCAs on USFS lands				x	
Remove riparian roads				x	x
Riparian protection					x

Strategy and action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
6. Restore natural hydrograph components					
Ag water conservation	x	x	x	x	
Improve irrigation conveyance	x	x	x		x
Orchard Ridge/Wolf Run	x				
Urban conservation	x				
Convert water rights	x	x	x	x	x
Regulate water withdrawals	x	x	x	x	x
Other nat hydrograph measures	x	x	x	x	x
Water retention structures		x			
Increase pool habitat (beav ponds)			x		
Floodplain aquifer recharge			x		
Enhance hyporheic flows					x
Recharge shallow aquifers					x
Aquifer storage & recovery					x
Umatilla Basin Project Phase I and II				x	
Umatilla Basin Project Phase III				x	
ISWRs				x	x
H2O rights transfer downstream				x	x
Water storage investigate					x
No new H2O appropriation					x
Criteria for new H2O appropriation					x
7. Improve degraded water quality					
Manage irrigation return flow	x	x	x		
Measures to improve DO	x	x			
Reduce chemical pollution	x	x	x		
Implement Ag WQP	x	x			
Other water quality measures	x	x	x	x	x
TMDL monitoring	x	x	x		
Increase riparian shading			x		
Reduce mine discharge toxicants			x		
Animal feeding BMPs			x		
Point source pollution controls				x	x
H2O quality mgmt plans				x	x
Pest mgmt plans for fruit growers					x
Municipal stormwater mgmt					x
Waterway alteration permitting					x
Permitting for H2O quality activities					x
8. Restore upland processes to reduce erosion					
Convert till farming	x	x	x		
Convert to perennial crops	x	x			
Implement IFPnet plans	x				
BMPS to reduce soil erosion	x	x			
Remove junipers		x			
Restore native upland plants		x	x	x	x
Improve/remove forest roads		x	x	x	x
Reforest/fuels management		x			
Upland demo projects			x	x	x
Invasive plant mgmt & junipers			x		
BMPs on land uses			x	x	x
Remove noxious weeds					x
CREP & CCRP buffers					x
Outreach to upland users					x

Part 1 for deriving action effectiveness asks: *What stream reaches will be affected by each of the actions?* The stream system in each of the five subbasins is delineated into a large number of reaches in EDT, each reach being precisely defined in how it is connected both upstream and downstream. In addition, reaches are aggregated into population units using the ICTRT population boundaries. The number of reaches in each subbasin that actions could potentially affect is listed below:

Subbasin	No. reaches
Fifteenmile	49
Deschutes	206
John Day	1,158
Umatilla	331
Walla Walla	220
Total	1,964

The planning teams identified the stream, and in many cases portions of streams, where each action would be targeted. They also designated which streams, or portions thereof, would be given high priority (priority 1) for action implementation or a lower priority (priority 2) for treatment (see Section 9).

Some actions would involve the direct manipulation of conditions within a stream reach, such as by riparian fencing along the reach, while others would act in areas removed from the stream (such as in the uplands) but would then affect reaches draining the affected area. In both cases, there would be one or more stream reaches affected within an area of highest influence by the action, with the potential for a dispersal of effects then moving downstream to other reaches. The Action Mapper was used to map the assumed distribution of effects associated with each action, as streams and reaches designated for action implementation were described in Section 9. A linear form of mapping is used in how reaches are shown arranged in the tools, lending itself to doing this task efficiently. For many actions, effects were assumed to not continue downstream beyond the area of direct influence due to the many factors that would need to be taken into account, such as other influences affecting downstream conditions. Generally, actions meant to affect flow and the hydrograph were extended downstream the furthest, as these actions would presumably be designed for that purpose.

The second part of deriving action effectiveness consisted of explicitly defining distinct elements—or factors—that are used to compose the overall effectiveness value applied in the analysis. Five elements of action effectiveness were recognized (Figure 10-3), each acting as a scalar to determine how effective an action would be in moving an attribute's current baseline rating back toward the undeveloped state. Combined, these scalars produce the realized effectiveness $REffect$ for action i, at lag time t, for attribute a used in modeling the action as follows:

$$REffect_{i,t,a} = Effect_i \times Intensity_i \times Lag_{i,t} \times Schedule_{i,t} \times Attribute_{a,i}$$

where $Effect_i$ is the potential effectiveness of action *i*

$Intensity_i$ is a scalar for defining the scale at which action *i* is to be applied

$Lag_{i,t}$ is a scalar that defines how much of the potential effectiveness of action *i* will be achieved at time *t* in the future (25 or 100 years in the future)

$Schedule_{i,t}$ is a scalar that defines an implementation schedule effect, i.e., whether implementation is delayed to some point in the future, whereby the amount of the potential effectiveness of action *i* would be reduced at time *t* in the future (25 or 100 years out)

$Attribute_{a,i}$ is a scalar that defines whether the potential effectiveness of action *i* for attribute *a* is the full amount (scalar of 1) or reduced due to an attribute effect. A scalar of 0 would indicate that the attribute is not affected by action *i*.

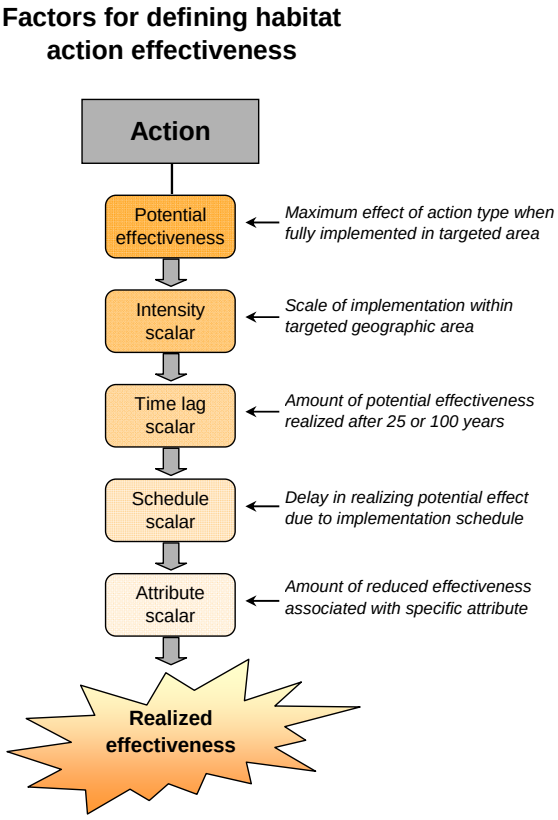


Figure 10-3. Action effectiveness elements.

An action's potential effectiveness ($Effect_i$) identifies the magnitude of effect that might reasonably be expected when the action would be implemented as fully as feasible within a geographic area. For example, how much of a stream reach 5 miles in length might reasonably be treated with a riparian restoration action (called Restore Riparian Communities in Table 10-2) if the action was focused on that reach—and, in turn, to what extent would the action restore attributes largely tied to the riparian condition in the pre-altered state? If the action remained in effect until its full benefit was to be realized—for this action perhaps 100 years—what would be its measured effectiveness at that time? In this case, we could reasonably argue that the full 5 miles could be treated and that after 100 years certain attributes (e.g., temperature, wood loading) might be restored completely (100%) to their pre-altered state. We assumed for the riparian restoration action a somewhat more conservative assumption—for this action, we applied an effectiveness value of 80%.

The potential effectiveness defines the maximum, yet reasonable, extent of effectiveness that might occur for the action of that type. Considering this aspect of an action's effectiveness provides a straightforward way of identifying a base effectiveness, to which the other scalars can then be applied. The potential effectiveness value assigned to each action is an assumption, since there are usually limited empirical data for defining the value with high degree of certainty. The assignment of effectiveness values to actions in recovery planning is often done through a team effort, either by consensus or as an average of values from different individuals (Mobrand Biometrics Inc 2003; Thompson et al. *in press*). Here, in this recovery planning process, the values were developed by one person using values from many previous efforts and who has facilitated a wide variety of team-oriented approaches in the Pacific Northwest.[8] This provided a consistent means of assigning effectiveness values for the entire set of actions considered across the five subbasins. To simplify the task of assigning potential effectiveness values, selections were made from 6 different levels, ranging between no effect to very high (Table 10-3) (See Appendix H for details).

Table 10-3. Potential effectiveness levels assigned to actions.

Effectiveness level	Definition	Effect
1	Very high	0.80
2	Moderately high	0.56
3	Moderate	0.32
4	Low	0.08
5	Negligible	0.01
6	No effect	0.00

[8] / Effectiveness modeling here was performed by Larry Lestelle, one of the principal architects of EDT, who has facilitated numerous EDT analyses in many watersheds of the Pacific Northwest. The perspective gained and actual effectiveness values used in those recovery planning efforts, in which the extent and causes of habitat degradation were assessed from pre-development conditions, gave an informed, consistent way of considering effectiveness of moving habitat conditions back toward their prior state.

The intensity scalar ($Intensity_i$) defines the average scale at which an action would actually be expected to be applied to the areas identified for treatment. In most cases, we would not expect actions to be applied at the maximum extent possible, given constraints imposed by land ownership patterns, various on-going land uses, and costs. The planning teams identified streams, and in many cases portions of streams, where specific actions would be targeted. They did not identify the extent that the actions would be applied within each of the targeted streams.

Continuing with the example of a five-mile reach where a riparian action would be applied, what portion of the reach would actually be expected to be treated? It would be reasonable to expect that some reaches might be treated in their entirety, while others would be treated at a much lower rate due to land ownership issues or other constraints imposed by on-going land uses. Actual project planning for implementing the tributary habitat actions will involve identification of opportunities and constraints and closely working with local stakeholders and planning entities.

Lacking some detailed planning information, we assigned an assumed level of intensity for each action, depending on action type and our understanding of how such actions have been implemented in the past. Initially, we considered varying the intensity scalar by the size of the subbasin (less intensity to larger subbasins). However, the larger subbasins also support multiple steelhead populations. We concluded that the analysis should be comparable between populations and applied identical intensity values between subbasins for the same action. Differences in how the actions would be applied in actuality are assumed to be reflected in the distributions of actions identified by the planning teams. To simplify the task of assigning intensity values, we chose from five different levels of intensity, ranging between negligible to very high (Table 10-4)(See Appendix H for details.)

Table 10-4. Intensity levels assigned to actions.

Intensity level	Definition	Scalar
1	Very high	0.85
2	High	0.40
3	Moderate	0.15
4	Low	0.05
5	Negligible	0.02

The lag scalar ($Lag_{i,t}$) defines how much of the potential effectiveness of an action will be achieved after a period of some number of years into the future. The full effectiveness of some actions would be realized immediately upon implementation (e.g., barrier removal), while others would require a lengthy time period to realize full effectiveness, such as riparian restoration. Two time lags were analyzed: 25 and 100 years into the future. All actions were assumed to be fully effective (lag scalar = 1) after 100 years, whereas the scalar was <1 at 25 years for those actions requiring a longer period to achieve full effectiveness. (See Appendix H for details.) Actions that would mature in effectiveness over time are those associated with maturing of

native vegetation, channel and floodplain reformation and stabilization, and the gradual restoration of more normative hydrographs as best management practices are instituted and realized.

The implementation schedule scalar ($Schedule_{i,t}$) defines how the schedule for implementing an action—relative to what might be considered year 0 of a recovery program—would affect realized effectiveness in either year 25 or year 100 of the program. Use of this scalar in the analysis recognizes that the recovery programs will be long-term in implementation due to their very extensive scope. Only a small fraction of the program can be expected to be implemented in the first year of the program. The scalar accounts for the reduced number of years an action might be operating between year 0 of the program and year 25 or year 100 considered in the analysis. The scalar $Schedule_{i,t}$ can be computed as:

$$Schedule_{i,t} = \frac{Y_t - Y_{imp}}{Y_t}$$

where Y_t is the number of years in the future of interest, here either 25 or 100 years

Y_{imp} is the year number into the program when action *i* is implemented.

If, for example, an action's potential effectiveness is 80% with a lag scalar of 50% at year 25, but it is implemented in year 10 of the program instead of year 0, then it's realized effectiveness in year 25 would be (ignoring intensity and attribute scalars):

Potential effectiveness	0.8
Lag scalar at 25 years	0.5
Schedule scalar at year 25	=15/25 = 0.6
Realized effectiveness at 25 years	= 0.8 x 0.5 x 0.6
	= 0.24

The planning teams for each subbasin generally identified how many years it would take before each action could be expected to be fully implemented in the subbasin. Actions were classified as being implemented immediately or in the short term (taking between 0-3 years from the start of the program to fully implement), or over an intermediate term (taking 4-14 years from program start to complete), or over a longer term (taking 15-25 years to complete). We approximated the implementation year for each action by taking the midpoint of the appropriate interval of years for completing the action and dividing by two (hence the median year by when half of the action would be expected to have begun).

The attribute scalar ($Attribute_{a,i}$) defines whether the potential effectiveness of an action will be the full amount (scalar = 1) or reduced due to an attribute effect. Some actions will have no effect on some attributes (scalar = 0). For each action, attributes were identified as being affected or not affected. We assigned the scalar to be 1 for any attribute that would be affected except for those that characterize some aspect of sediment, flow, and temperature. We set the

scalar for these to be 0.75, recognizing that these attributes are broadly affected by watershed conditions and can be more difficult to influence than attributes driven mainly by site-specific conditions. It is noted, however, that the distributions of many actions were identified by the planning teams to extend well into the headwater areas of streams. (See Appendix H for details.)

The example shown above is extended below to include all of the scalars, here shown with a moderate intensity of application as applied to the attribute maximum water temperature:

Potential effectiveness	0.8
Intensity scalar	0.15
Lag scalar at 25 years	0.5
Schedule scalar at year 25	0.6
Temperature attribute scalar	0.75
Realized effectiveness at 25 years	= 0.8 x 0.15 x 0.5 x 0.6 x 0.75
	= 0.027

In this example, the resulting realized effectiveness is calculated to be 0.027, meaning here that in the affected stream reach the maximum water temperature rating would be moved 2.7% of the distance between the current and the pre-altered ratings.[9]

Fish Passage Actions

The planning teams identified actions to provide for fish passage at sites known or assumed to be full or partial physical barriers to fish migration. Restoration of fish passage at each of these sites was modeled if the barrier had been identified and incorporated into the EDT database when the reach characterization was completed during the subbasin planning process. In some cases, these barriers had not been incorporated. In those instances, our analysis assumed that the problem had already been resolved.[10] Except in the case of the Pelton-Round Butte Complex in the Deschutes system, we modeled passage actions as providing full (100%) passage for both upstream and downstream migrations.

The Pelton-Round Butte Complex is the most significant barrier to fish migration addressed in the analysis. Passage around this hydro-electric project on the mainstem Deschutes River was terminated in 1968, blocking anadromous fish from returning to major spawning areas in that river. Work is currently underway to restore both upstream and downstream passage at the

[9] / To illustrate the effect, the current condition for maximum water temperature within a stream reach might have a rating of 3.5, which is equivalent to peak temperatures reaching 22-25 C on multiple occasions during a month. If the historic temperature—given what can reasonably be assumed about riparian condition, wet meadows, flow, etc—was much cooler, here having a rating of 1.0 meaning that temperatures normally did not exceed 16 C during the month, then the action would result in a rating of 3.43 ((3.5 – 1) x (1 – 0.027) + 1= 3.43), a very slight improvement from the current condition. The ratings for each attribute are used in the EDT rules to compute survival effects by life stage and species (see Lestelle et al. 2004).

[10] / We left the reach characterizations intact as they had been formulated during the subbasin planning process. If a barrier had not been incorporated in that process, it suggests that a passage problem had already been rectified at the time that the planning process was performed or there is uncertainty about the true state of the potential barrier. Regardless, our modeling in such case was performed assuming that a barrier did not exist if it had not been identified in the EDT database.

facilities. Uncertainty exists about how effective passage will be due to the nature of conditions within Lake Billy Chinook. In our analysis, we applied passage assumptions provided by Don Ratliff with Portland General Electric (personal communication), listed below:

Upstream passage effectiveness	99%
Downstream passage effectiveness	75%

As part of the action to restore passage at the Pelton-Round Butte Complex, we also incorporated an option to restore passage at water diversion sites within Whychus Creek. This aspect had not been explicitly called for in actions provided by the planning team. However, Whychus Creek provides the greatest amount of potential spawning habitat for the Deschutes Westside steelhead population upstream of the Pelton-Round Butte Complex—it is logical to assume that barriers in that stream would be addressed.

10.1.3 All-H Integration Across Life Cycle

The AHA model was used to incorporate potential effects of hatchery programs on the genetic fitness of the naturally-produced populations.

Genetic Fitness Effects
The AHA model incorporates key concepts and assumptions about the effects of genetic interactions between hatchery and natural fish built on the work of Lynch and O'Hely (2001) and Ford (2002), with further development of those ideas by geneticists working with the Hatchery Scientific Review Group (Mobrand – Jones & Stokes 2005). Fitness is computed in the model using Ford's (2002) modeling equations.

Ford (2002) used a quantitative genetic model to examine how the combined effects of selection in two environments, hatchery and wild, can influence the distribution of a phenotypic trait and the fitness of a salmon population. The model incorporates assumptions about the strength of selection in hatchery and wild environments, the rate of exchange between the two populations, the maximum reproductive rates of the population in each environment, and the duration of hatchery influence. Modeling results showed that when the hatchery population is closed to gene flow from the natural population, even low levels of gene flow from the hatchery population to the natural population will shift the natural population's mean phenotype so that it approaches the optimal phenotype in the hatchery. If the hatchery population receives gene flow from the natural population, such as by incorporating natural fish into the brood stock, the shift in the natural population's mean phenotype is reduced. While the fitness consequences of such shifts depended on model assumptions, a decline of over 30% in fitness occurred over a broad range of parameter values. When selection was assumed to be relatively strong, the fitness of the natural population was reduced by 80% or more if the hatchery population was closed to immigration from the natural population. The natural population was protected from such fitness decline only when gene flow from the hatchery to the natural population approached zero. Weaker selection produced less dramatic fitness loss, but even very weak selection could produce large reductions in fitness if the hatchery population was closed to immigration from the natural population.

The HSRG concluded (Mobrand et al. 2005) on the basis of AHA modeling that stray hatchery-origin fish from genetically-segregated populations can have a significant genetic influence on natural-origin populations after several generations when their proportion of the total naturally spawning population exceeds 5%. Consequently, they have recommended that hatchery-origin spawners from segregated programs not be allowed to exceed 5% of the natural-origin spawners as an upper-limit guideline. The HSRG is using the AHA model to evaluate potential genetic interactions between hatchery and natural fish associated with hatchery programs in much of the Pacific Northwest, including within the Columbia Basin. In most cases, the model is applied using the HSRG's default parameter settings for the model (Lars Mobrand, personal communication).

In examining genetic effects associated with default model settings, we concluded that one modification was needed. The default setting for what Ford (2002) defines as the optimal trait value in the hatchery environment results in a rapid and severe decline in the natural-origin population's fitness (recruits per spawner) as the proportion of strays exceeds about 5% (dashed line in Figure 10-4). As the proportion of strays continues to increase, equilibrium fitness bottoms out at approximately 20% of the natural-origin population unaffected by strays. (The dashed line in Figure 10-4 corresponds to the line in Ford's Figure 3A associated with a theta of -20, which can be seen there as having a very severe effect relative to other possibilities.) We find this level of severity to be unrealistic as it would have already caused extinction to several Mid-C steelhead populations. Lars Mobrand (personal communication) reports that the HSRG has reached the same conclusion, though they address these by truncating the effect on fitness at 50%, which they suggest is a likely worst case effect. Truncation in this manner results in a very precipitous decline in fitness at relatively low levels of strays, then an abrupt floor on fitness effect when 50% is reached. The 50% effect occurs with about 7-8% of the natural spawning population consisting of strays.

We assume that a 50% floor on fitness effect is reasonable and have applied it in our modeling. However, we modified the optimal trait value in the hatchery such that a floor of 50% would be attained while providing for a smooth transition across a relatively wide range of strays (solid line in Figure 10-4). This setting for the hatchery optimal trait value also provides a less precipitous decline in fitness though it still results in a very strong effect when strays are 10% or more of the naturally spawning population.

In our analysis of genetic effects of hatchery fish, we applied the AHA model primarily to consider interactions of stray hatchery fish with the natural-origin populations being analyzed. The average proportions of strays in the naturally spawning populations for the baseline and current time periods used in the analysis are identified in Appendix B in the spawner composition SS/D metric for each population. These proportions would decline with increased natural-origin run sizes for scenarios involving tributary habitat actions, since numbers of strays would be unchanged.

Prospective actions to manage the numbers of strays were analyzed for the two Deschutes populations. Although there are no significant proposed actions to reduce strays in the John Day River populations, we do plan to model reductions in the future for reference information. The numbers of strays in the natural spawning populations would be reduced to 5% of the number

entering the spawning areas, such as by using weirs. We assumed that the ratio of Round Butte hatchery strays to out-of-DPS hatchery strays would remain unchanged from the baseline ratios. The number of strays that enter a subbasin could increase above baseline levels, however, due to improved survival in the mainstem Columbia River associated with actions to improve survival.

We also used the model to incorporate genetic effects for the within-population hatchery program associated with the ten populations analyzed, that being the Umatilla supplementation hatchery program. Potential genetic effects of that program were incorporated into our analysis by using the modeling inputs for the program as being applied by the HSRG.

We used the default parameter settings in AHA to analyze fitness except as noted above.

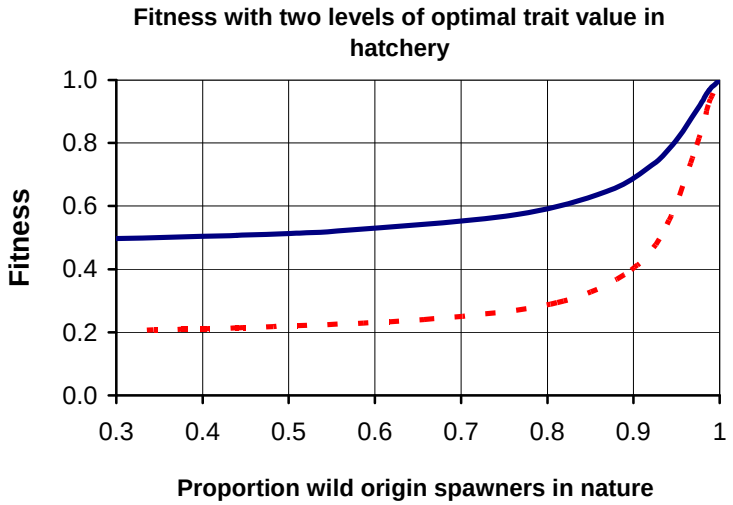


Figure 10-4. Change in fitness in relation to proportion of strays used in AHA modeling. Dashed line represents the default AHA settings based on Ford (2002). The solid line represents the relationship used for modified AHA in these analyses.

Out-of-Subbasin Factors and Actions

Out-of-subbasin actions were modeled using projected survival improvements as presented in Table 10-5. Projected survival improvements are consistent with values given in the most recent Biological Opinion issued by NOAA Fisheries on October 30, 2007. Use of the BiOp survival improvement values in no way implies endorsement of the validity of the estimates or the adequacy of the actions for recovery. At this time, the BiOp survival improvement estimates for the hydrosystem, predation, and estuary actions are the only estimates available for these proposed actions.

Scenarios were run in a stepwise fashion, starting with baseline, then current condition, then adding in actions sequentially, each being added to the previous scenario. The effects of hatchery steelhead programs on genetic fitness—hence performance—of natural-origin fish were incorporated for each scenario using AHA.

Table 10-5. Out-of-subbasin survival improvements for Mid-C steelhead populations. Improvement factors are expressed as multipliers on survival and are derived as ratios of estimated survival in one period divided by the previous period.

Mainstem river survival factor	Affected populations	Current/base ratio	Future/current
Hydro			
1 dam	Fifteenmile	1.031	1.002
2 dam	Deschutes	1.064	1.051
3 dam	John Day, Umatilla	1.103	1.100
4 dam	Walla Walla	1.143	1.122
Predation			
Avian	All	0.997	1.034
Pikeminnow	All	1.000	1.010
Estuary	All	1.003	1.057
Harvest	All	1.040	1.000

10.2 Analysis of Tributary Habitat Action Effectiveness

Results of the tributary action analysis are presented for each population below. Changes in performance measures associated with each action scenario are presented for intrinsic productivity, equilibrium (or average) abundance, and life history diversity, as these metrics were described earlier in this section.

For each population, the following results are presented in tabular and/or graphic form:

- Summary of level of action coverage, reporting
  - Stream miles within the subbasin relevant to the population
  - Number of actions applied;
  - Cumulative miles of stream potentially affected by all actions (ignoring intensity of application);
  - Ratio of cumulative miles potentially affected by stream miles relevant to population;
  - Average action effectiveness applied, weighted by the number of stream miles potentially affected per each action;
  - Average adjusted effectiveness, weighted by the number of stream miles potentially affected, where effectiveness is adjusted for all scalars (such as intensity of treatment) except the attribute scalar (therefore the actual adjusted effectiveness is lower for some attributes); and
- Summary of estimated percent changes in population performance for each population due to the tributary habitat actions for each scenario; and
- Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions. Habitat potential here is assumed to be equal to the population performance that would have occurred associated with the pre-

development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place; and

- Maps illustrating geographic areas that are currently in protected status (wilderness areas, proposed wilderness areas, and municipal watersheds, USFS 2009 personal communication); stream reaches where priority 1 and priorities 1 and 2 protection actions are proposed; and, restoration benefits from priority 1 and priorities 1 and 2 restoration actions for all reaches.

Genetic effects to populations due to hatchery-origin fish spawning with natural-origin fish are not considered in this part of the analysis. Genetic effects are incorporated as part of the all-H integration.

10.2.1 Fifteenmile Creek Winter Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions in the Fifteenmile subbasin is greater than for any of the coverage amounts for the other populations analyzed. The ratios of cumulative miles potentially affected by actions to total stream miles available exceed 20 for both Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-6 summarizes tributary habitat action coverage and average action effectiveness values applied to the Fifteenmile Creek winter steelhead population.

Table 10-6. Summary of tributary habitat action coverage and average action effectiveness values applied to the Fifteenmile Creek winter steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar.

Population:	Fifteenmile Creek	
Total stream miles in subbasin:	134	
	Priority 1	Priority 1 & 2
No. of actions:	39	39
Cum miles affected by actions:	2,799	2,987
Ratio cum miles affected to total miles:	20.9	22.4
Weighted ave potential action effectiveness 1/:	0.253	0.270
Weighted ave adjusted action effectiveness 1/:	0.050	0.051

1/ Weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Fifteenmile Creek winter steelhead from tributary actions are shown in tables 10-7 and 10-8, and figures 10-5 and 10-6. Estimated increases in population performance resulting from tributary habitat actions are relatively large for each performance measure for both 25 and 100 year scenarios (Figure 10-5). Between 50-70% of habitat potential (i.e., historical potential) for both abundance and productivity is estimated to be achieved for the four scenarios considered (Figure 10-6). Nearly 100% of habitat potential would be achieved as expressed by the life history diversity metric. It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays (fitness loss is assumed to be zero for this population).

Table 10-7. Estimated percent changes in population performance of Fifteenmile Creek winter steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	108%	134%
	Priority 1 & 2	119%	147%
Productivity	Priority 1	48%	90%
	Priority 1 & 2	55%	100%
Diversity index	Priority 1	166%	175%
	Priority 1 & 2	180%	185%

Table 10-8. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Fifteenmile Creek winter steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	32%		
	Priority 1		67%	75%
	Priority 1 & 2		70%	79%
Productivity	Baseline	35%		
	Priority 1		52%	67%
	Priority 1 & 2		55%	71%
Diversity index	Baseline	34%		
	Priority 1		91%	95%
	Priority 1 & 2		96%	98%

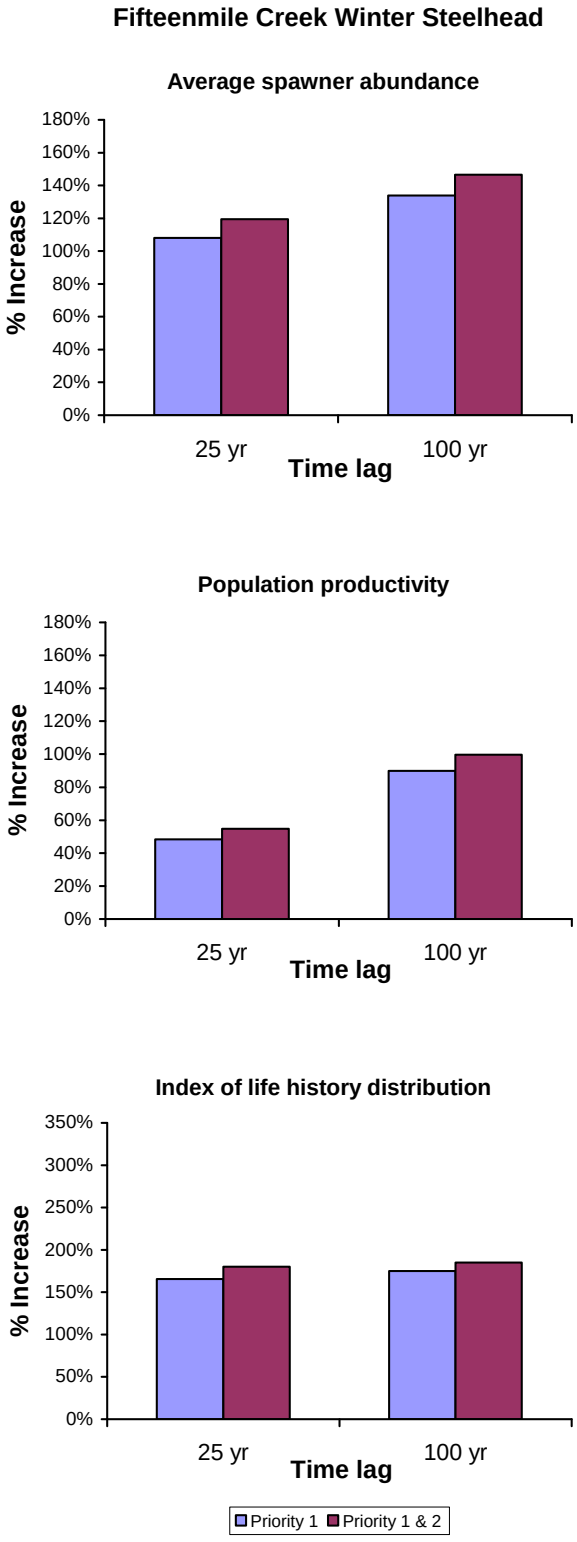


Figure 10-5. Estimated percent changes in population performance of Fifteenmile Creek winter steelhead due to tributary habitat actions.



Figure 10-6. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Fifteenmile Creek winter steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

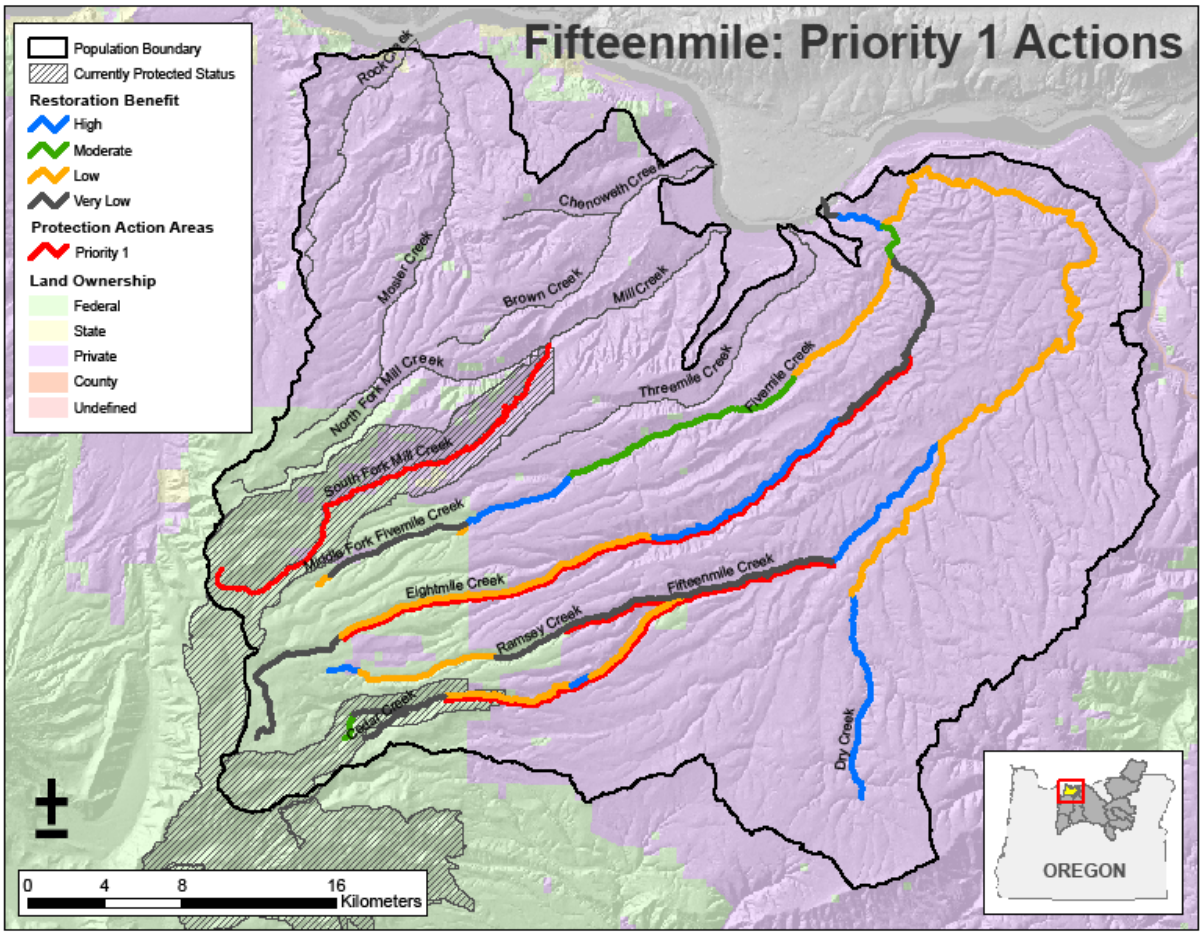


Figure 10-7. Map of the Fifteenmile Creek steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches. Restoration benefits are only shown for the Fifteenmile Creek watershed because no effectiveness modeling was completed for the other watersheds in the population.

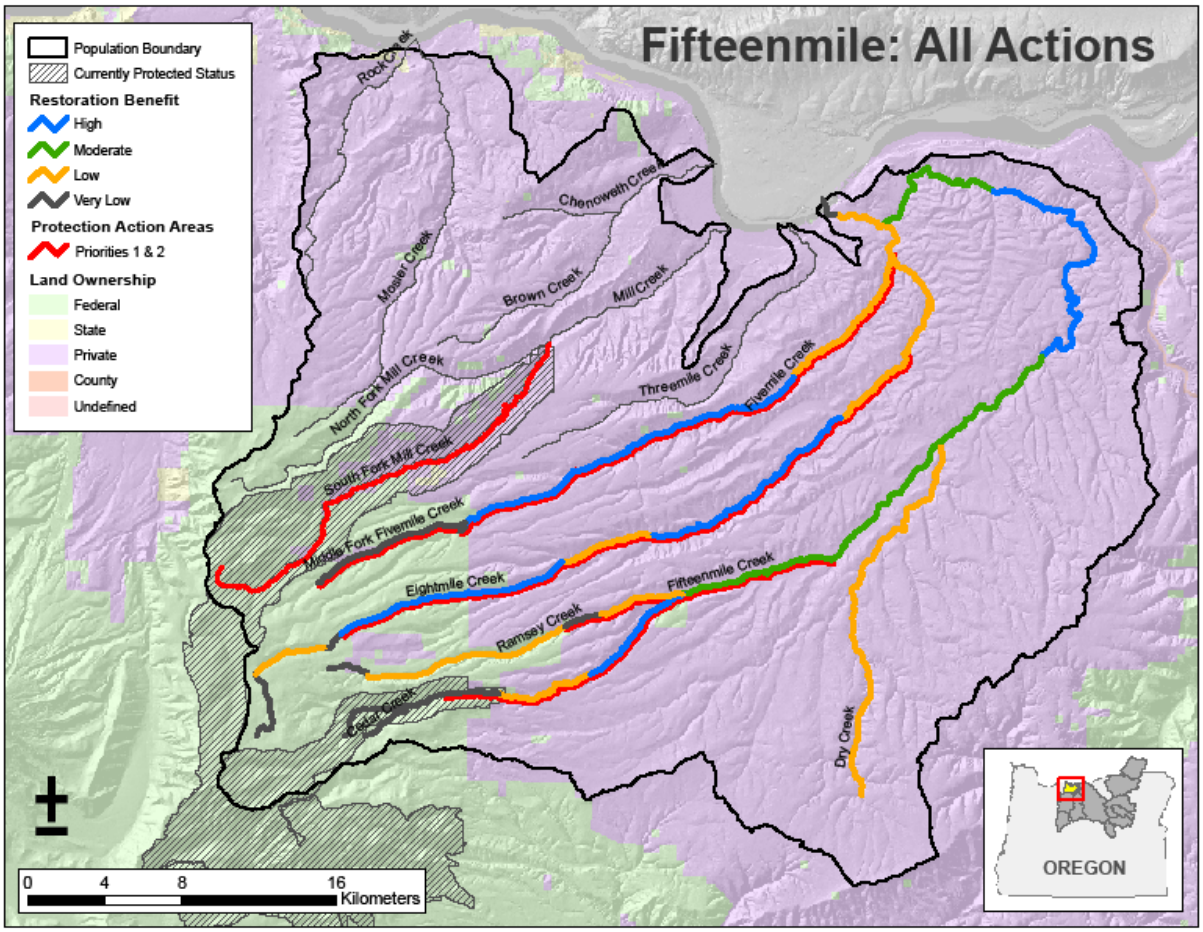


Figure 10-8. Map of the Fifteenmile Creek steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions. Restoration benefits are only shown for the Fifteenmile Creek watershed because no effectiveness modeling was completed for the other watersheds in the population.

10.2.2 Deschutes River Eastside Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the Deschutes River Eastside population is comparable to the coverages applied to most of the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are approximately 10 for both Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-9 summarizes tributary habitat action coverage and average action effectiveness values applied to the Deschutes River Eastside summer steelhead population.

Table 10-9. Summary of tributary habitat action coverage and average action effectiveness values applied to the Deschutes River Eastside summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire Deschutes subbasin.

Population:	Deschutes River Eastside	
Total stream miles in Deschutes subbasin:	802	
	Priority 1	Priority 1 & 2
No. of actions:	38	38
Total stream miles Eastside:	360	360
Cum miles affected by actions:	3,363	4,145
Ratio cum miles affected to total miles:	9.3	11.5
Weighted ave potential action effectiveness 1/:	0.136	0.170
Weighted ave adjusted action effectiveness 1/:	0.038	0.043

1/ Value shown is for entire Deschutes subbasin; weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Deschutes River Eastside summer steelhead from tributary actions are shown in tables 10-10 and 10-11, and figures 10-9 and 10-10. Estimated increases in population performance resulting from tributary habitat actions are relatively large for both 25 and 100 year scenarios (Figure 10-9). Between approximately 50-70% of habitat potential (i.e., historical potential) for abundance is estimated to be achieved for the four scenarios considered (Figure 10-10). The amount of habitat potential reached in productiviy is somewhat less, roughly between 25-45% of potential. These results indicate that

the habitat actions would have a greater effect on habitat quantity, since abundance is affected by both the quantity and quality of habitat, and productivity is primarily affected by habitat quality. Increases in water flow and opening of fish passage barriers would tend to affect habitat quantity more than quality characteristics on the whole. The largest amount of habitat potential regained by the actions would occur for the life history diversity measure. This measure of diversity reflects how much of the habitat could support sustainable life histories. The increase in diversity indicates that habitat quality and removal of barriers is sufficient to result in a substantial expansion of sustainable distribution within the geographic area of interest.

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-10. Estimated percent changes in population performance of Deschutes River Eastside summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	69%	107%
	Priority 1 & 2	102%	139%
Productivity	Priority 1	48%	98%
	Priority 1 & 2	79%	143%
Diversity index	Priority 1	137%	188%
	Priority 1 & 2	174%	219%

Table 10-11. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Eastside summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	28%		
	Priority 1		48%	58%
	Priority 1 & 2		57%	67%
Productivity	Baseline	18%		
	Priority 1		27%	36%
	Priority 1 & 2		32%	44%
Diversity index	Baseline	25%		
	Priority 1		60%	73%
	Priority 1 & 2		69%	80%

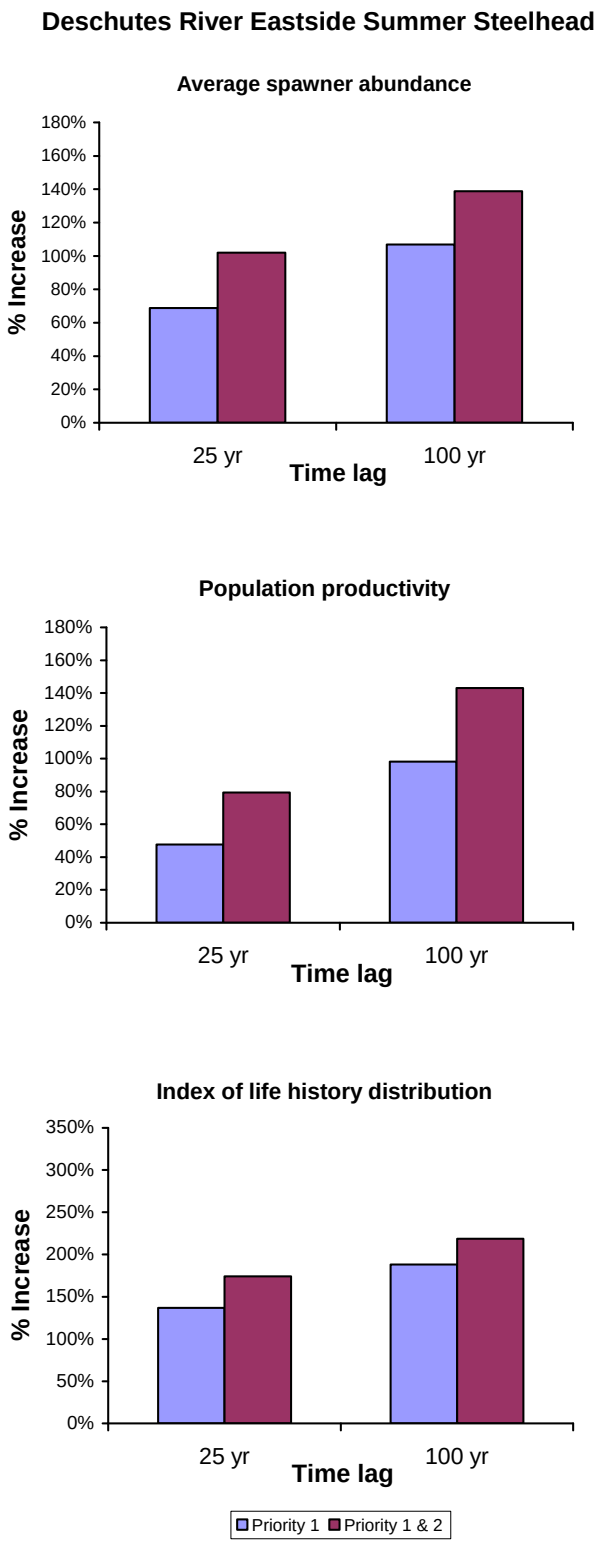


Figure 10-9. Estimated percent changes in population performance of Deschutes River Eastside summer steelhead due to tributary habitat actions.



Figure 10-10. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Eastside summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

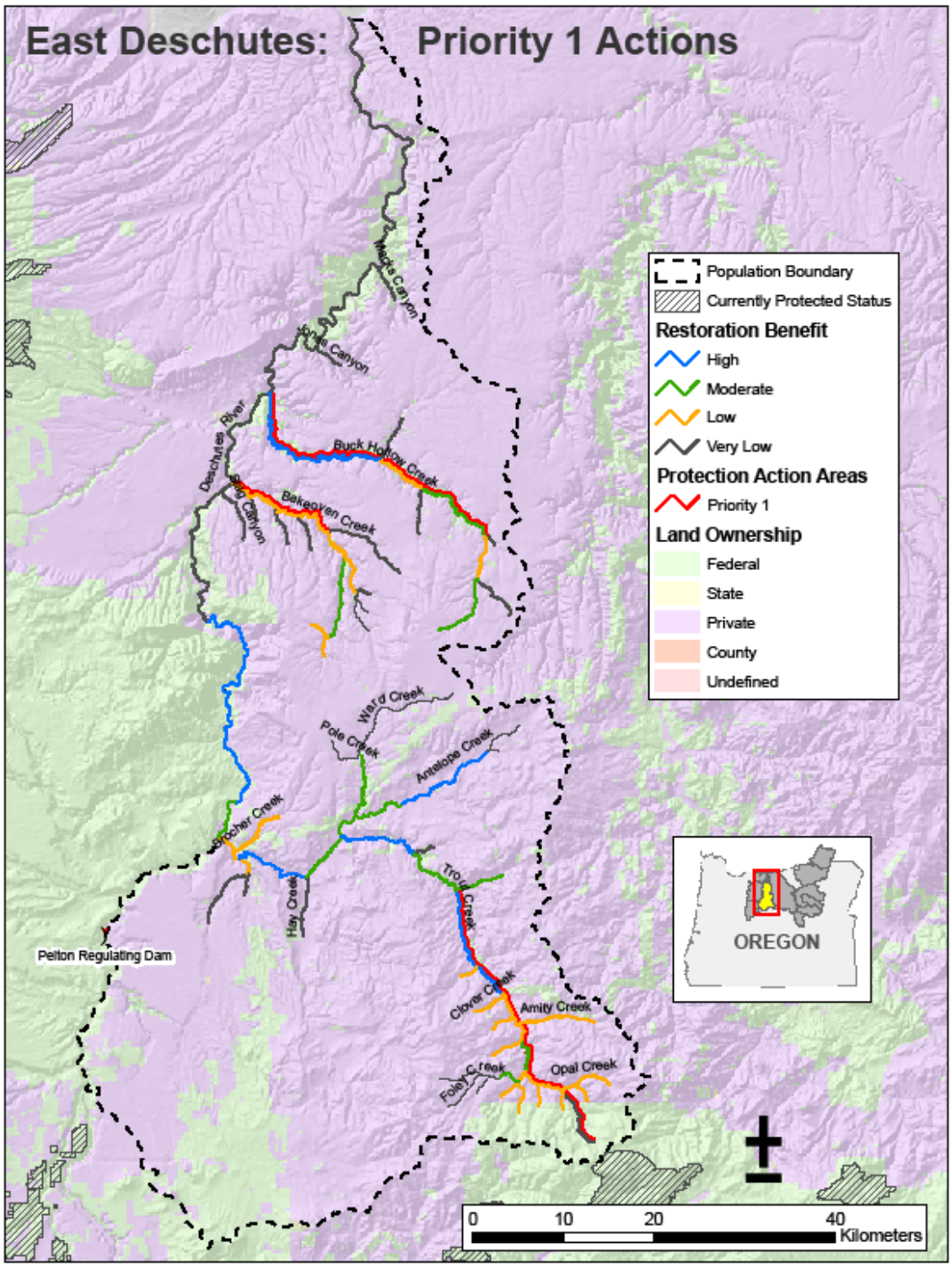


Figure 10-11. Map of the Deschutes River Eastside steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

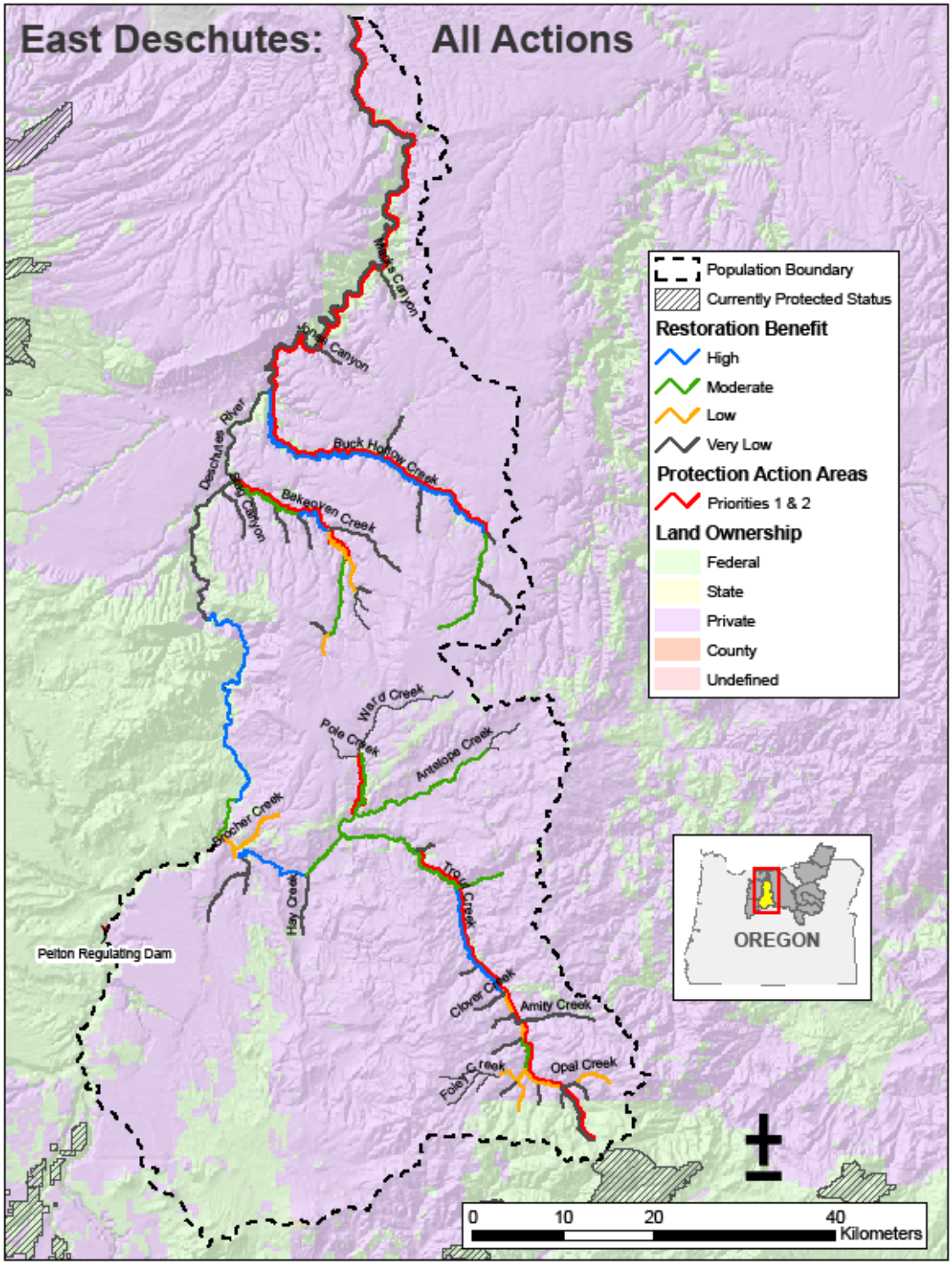


Figure 10-12. Map of the Deschutes River Eastside steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.3 Deschutes River Westside Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the Deschutes River Westside population is comparable to the coverages applied to most of the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are approximately 10 or slightly greater for both Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-12 summarizes tributary habitat action coverage and average action effectiveness values applied to the Deschutes River Westside summer steelhead population.

Table 10-12. Summary of tributary habitat action coverage and average action effectiveness values applied to the Deschutes River Westside summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire Deschutes subbasin.

Population:	Deschutes River Westside	
Total stream miles in Deschutes subbasin:	802	
	Priority 1	Priority 1 & 2
No. of actions:	38	38
Total stream miles in Westside:	442	442
Cum miles affected by actions:	4,341	5,935
Ratio cum miles affected to total miles:	9.8	13.4
Weighted ave potential action effectiveness 1/:	0.136	0.170
Weighted ave adjusted action effectiveness 1/:	0.038	0.043

1/ Value shown is for entire Deschutes subbasin; weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Deschutes River Westside summer steelhead from tributary actions are shown in tables 10-13 and 10-14, and figures 10-13 and 10-14. Estimated increases in population performance resulting from tributary habitat actions are modest for both 25 and 100 year scenarios in the absence of passage at the Pelton-Round Butte Complex (Figure 10-13). Estimated increases in spawner abundance associated with habitat actions are <20%, even after 100 years of action maturation. Estimated increases in productivity are larger, being between 35-55% greater at the 100 year time period in the absence of passage.

Increases in the life history diversity metric are smaller (<12%). With passage at Pelton-Round Butte Complex (and including passage at barriers in Whychus Creek), performance measures for abundance and life history diversity are markedly increased. In contrast, productivity is reduced slightly when passage occurs. A reduction in productivity can occur with passage due either to the opening of poorer quality habitat than below the barrier or to a toll on survival associated with fish passing the barrier. In this case, the slight drop in survival is apparently due to migration survival loss associated with passage (juvenile passage effectiveness was assumed to be 75%).

Without fish passage at Pelton-Round Butte Complex, less that 50% of the habitat potential (i.e., historical potential) for abundance is estimated to be achieved for the four scenarios considered (Figure 10-14). The amounts of potential for these scenarios are only slightly greater than the baseline level. These modest increases toward regaining lost habitat potential, given the extent of actions being applied, suggest that much of the historical potential that existed historically downstream of Pelton-Round Butte is already being achieved. This further suggests that one or more other factors are constraining the actual population's performance besides that determined by habitat condition. One factor, loss in genetic fitness due to hatchery strays, is addressed as part of the All-H integration later in this section. We hypothesize that a second factor is interaction with the resident life history form of *O. mykiss*. Our analysis, including both our detailed tributary action assessment and the All-H integration, does not address how the resident form of *O. mykiss*, may be constraining the performance of the anadromous population.

Table 10-13. Estimated percent changes in population performance of Deschutes River Westside summer steelhead due to tributary habitat actions. Results are shown with and without passage at the Pelton-Round Butte Complex. The passage scenarios also include passage at water diversion barriers on Whychus Creek.

Performance measure	Scenario	No passage		Passage	
		Time period lag			
		25 yr	100 yr	25 yr	100 yr
Abundance	Priority 1	5%	12%	50%	59%
	Priority 1 & 2	10%	17%	58%	68%
Productivity	Priority 1	22%	36%	19%	32%
	Priority 1 & 2	33%	54%	31%	50%
Diversity index	Priority 1	7%	10%	67%	70%
	Priority 1 & 2	9%	11%	69%	71%

Table 10-14. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Westside summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place. Results are shown with and without passage at the Pelton-Round Butte Complex. Passage scenarios include passage at diversions in Whychus Creek.

Performance measure	Scenario	No passage			Passage		
		Time period					
		Base/Curr	25 yr	100 yr	Base/Curr	25 yr	100 yr
Abundance	Baseline	43%			43%		
	Priority 1		45%	48%		64%	68%
	Priority 1 & 2		47%	50%		68%	72%
Productivity	Baseline	46%			46%		
	Priority 1		57%	63%		55%	61%
	Priority 1 & 2		62%	71%		61%	69%
Diversity index	Baseline	52%			52%		
	Priority 1		56%	57%		87%	88%
	Priority 1 & 2		57%	58%		88%	89%

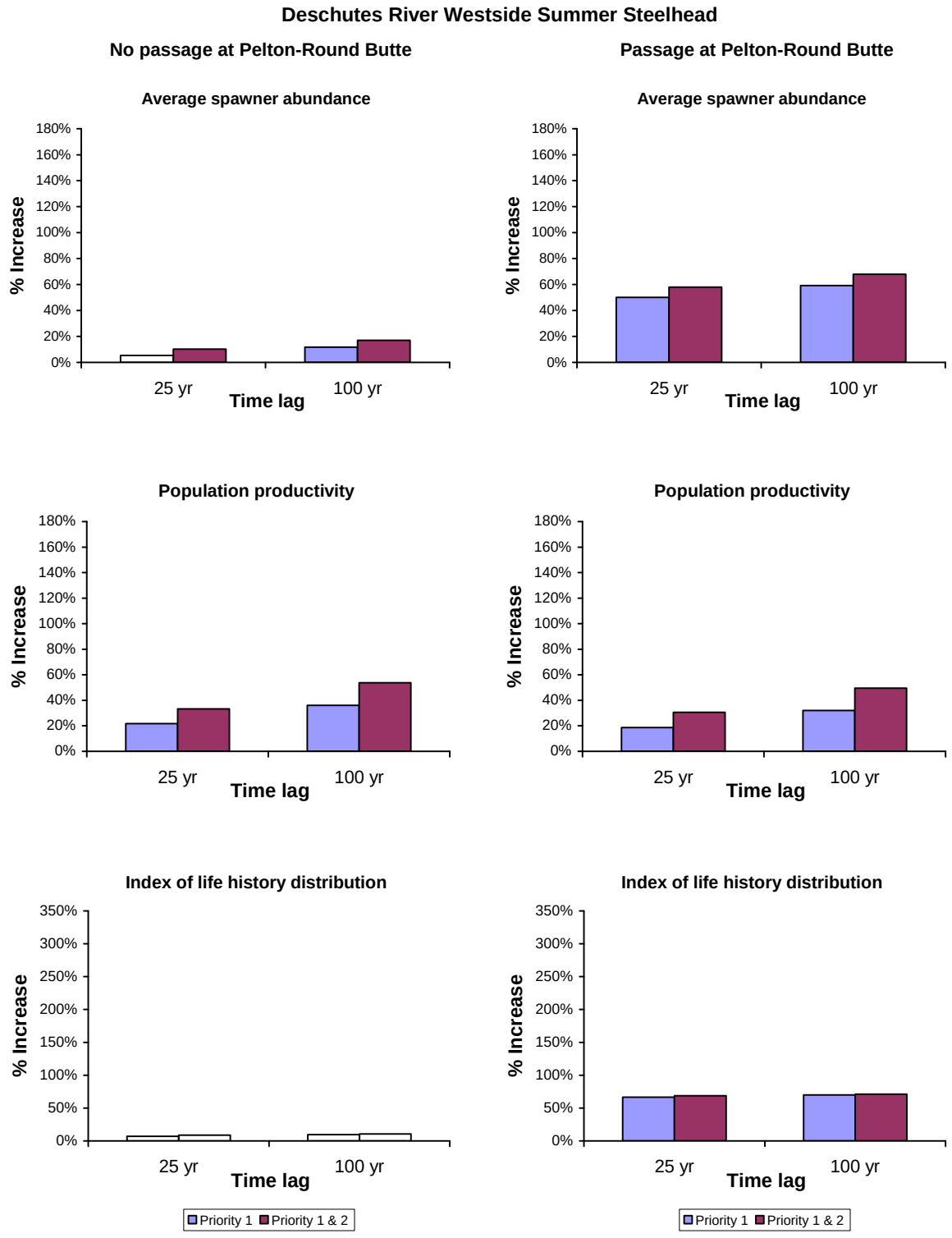


Figure 10-13. Estimated percent changes in population performance of Deschutes River Westside summer steelhead due to tributary habitat actions with and without passage at the Pelton-Round Butte Complex. Passage also includes passage at diversion barriers on Whychus Creek.

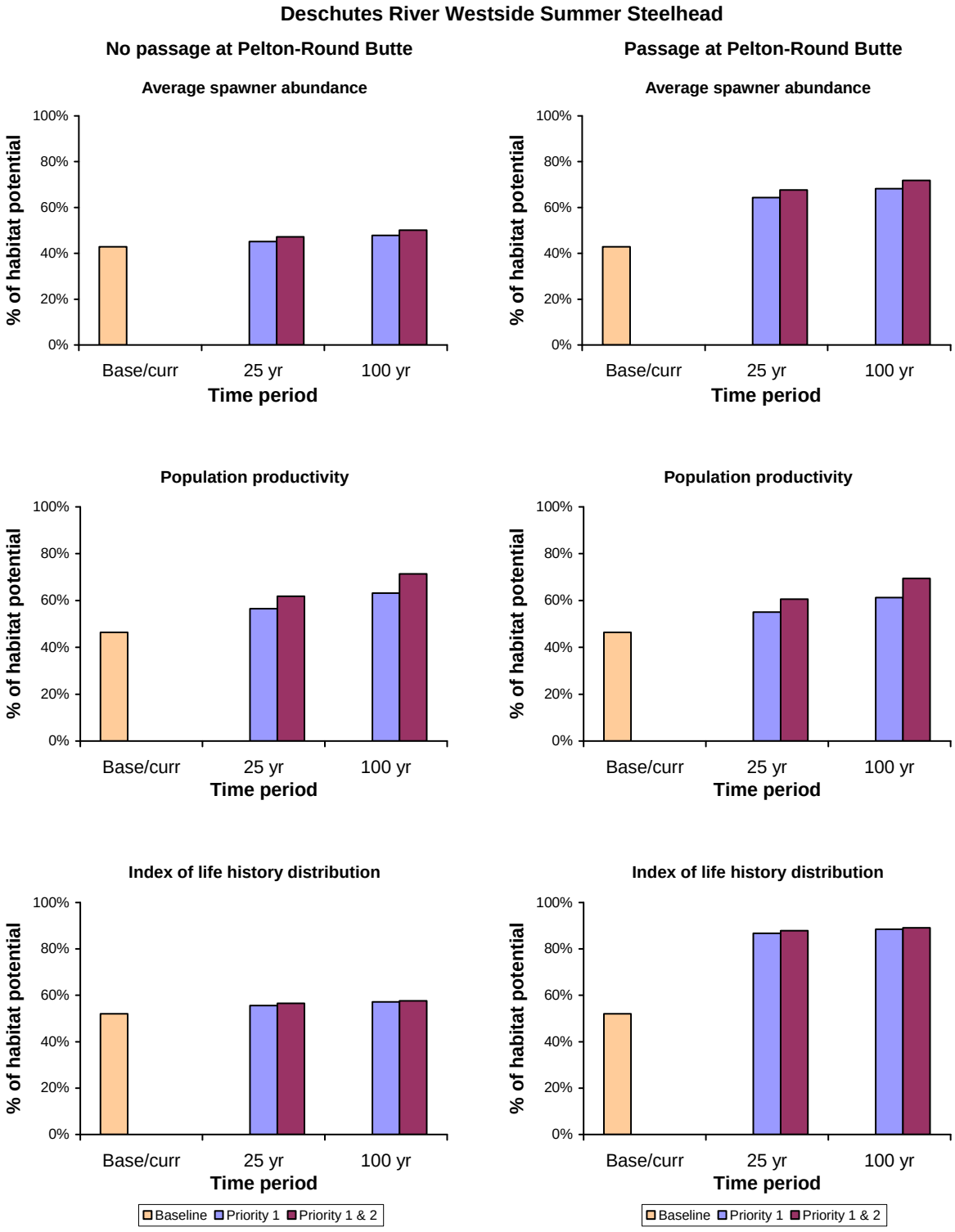


Figure 10-14. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Deschutes River Westside summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Results are shown with and without passage at Pelton-Round Butte Complex and Whychus Creek.

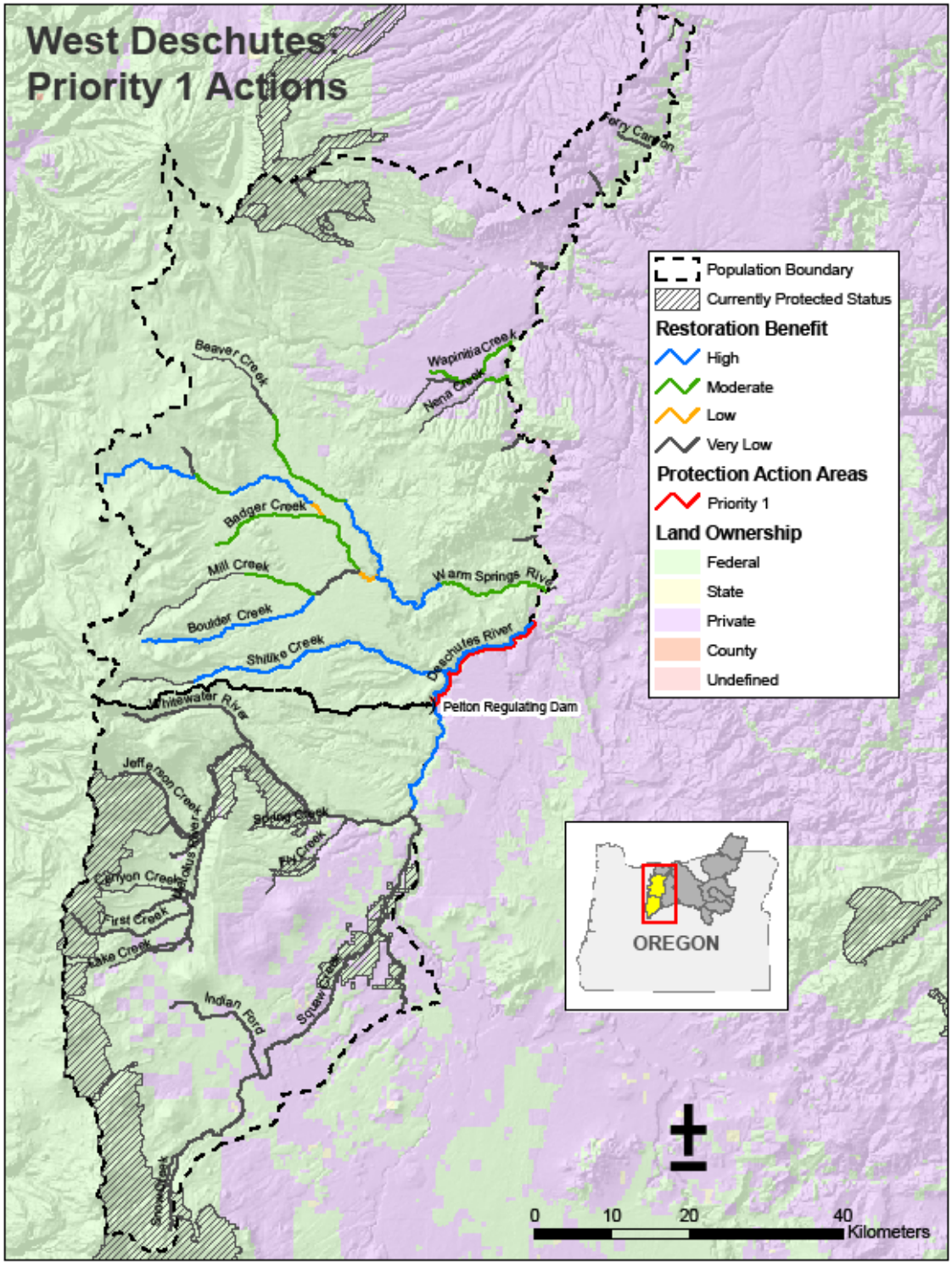


Figure 10-15. Map of the Deschutes River Westside steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

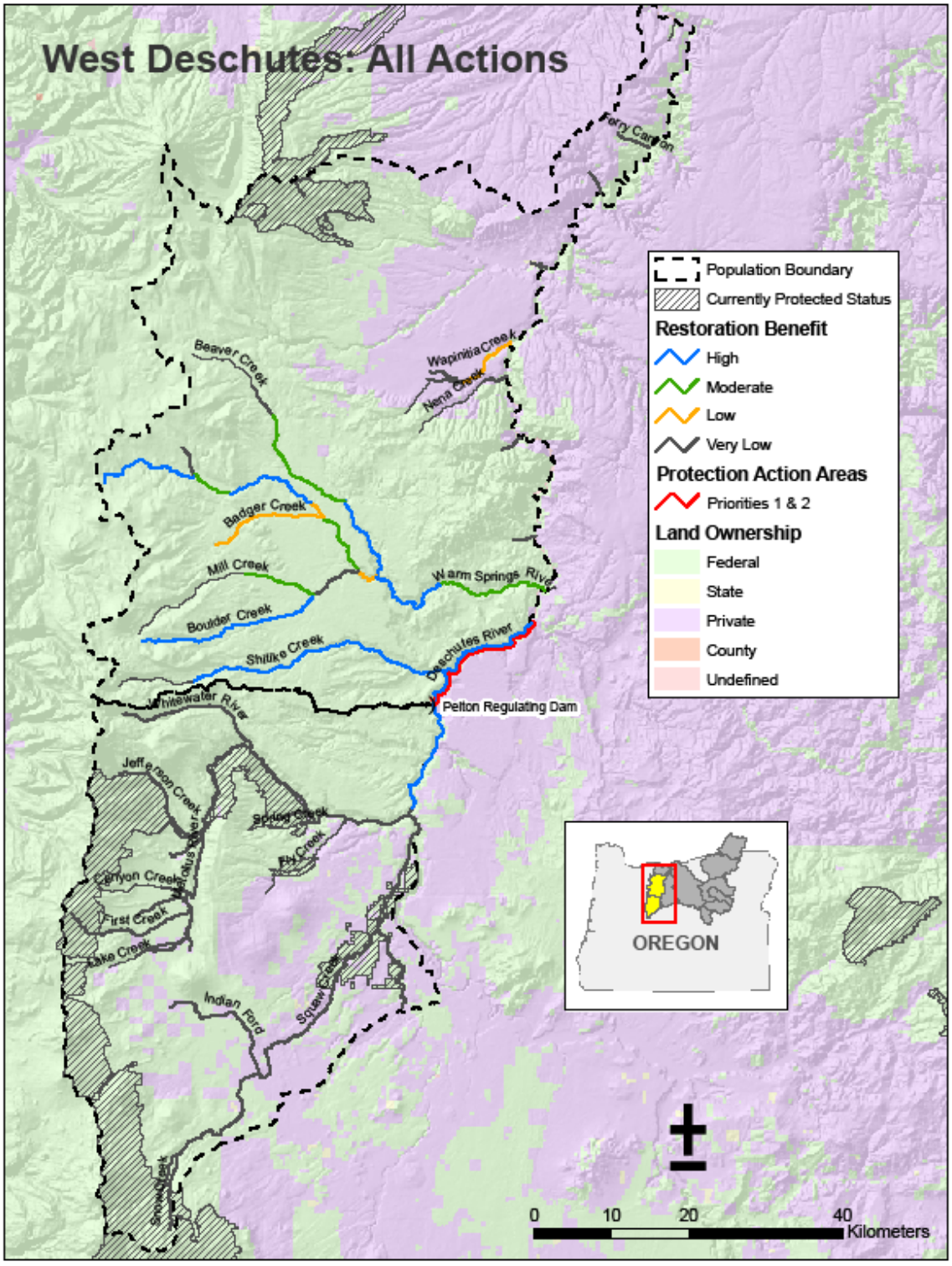


Figure 10-16. Map of the Deschutes River Westside steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.4 Lower Mainstem John Day River Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the Lower Mainstem John Day River population is comparable to the coverages applied to most of the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are approximately 10 or less for Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-15 summarizes tributary habitat action coverage and average action effectiveness values applied to the Lower Mainstem John Day River summer steelhead population.

Table 10-15. Summary of tributary habitat action coverage and average action effectiveness values applied to the Lower Mainstem John Day River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire John Day subbasin.

Population:	Lower Mainstem John Day River	
Total stream miles in John Day subbasin:	2,936	
	Priority 1	Priority 1 & 2
No. of Lower John Day actions:	37	37
Total stream miles in Lower John Day:	1,026	1,026
Cum miles affected by LowJD actions:	7,825	10,789
Ratio cum miles affected to total LowJD miles:	7.6	10.5
Weighted ave potential action effectiveness 1/:	0.145	0.146
Weighted ave adjusted action effectiveness 1/:	0.034	0.032

1/ Value shown is for entire John Day subbasin; weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Lower Mainstem John Day River summer steelhead from tributary actions are shown in tables 10-16 and 10-17, and figures 10-17 and 10-18. Estimated increases in population performance resulting from tributary habitat actions are relatively moderate to large, depending on the performance measure (Figure 10-17). The smallest percentage increases occur for productivity. Even with these increases, performance for both productivity and abundance achieve only approximately 30-40% of habitat potential

with actions. Amounts of potential for the baseline are only approximately 20% or less for these metrics. (Figure 10-18). The largest amount of habitat potential regained by the actions would occur for the life history diversity measure. Between 40-60% of potential associated with this metric would be achieved with habitat actions. The life history diversity metric reflects how much of the habitat could support sustainable life histories. An increase in diversity indicates that habitat quality and removal of barriers (when present) is sufficient to result in a substantial expansion of sustainable distribution within the geographic area of interest.

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-16. Estimated percent changes in population performance of Lower Mainstem John Day River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	64%	113%
	Priority 1 & 2	97%	177%
Productivity	Priority 1	24%	57%
	Priority 1 & 2	28%	83%
Diversity index	Priority 1	76%	121%
	Priority 1 & 2	143%	192%

Table 10-17. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Lower Mainstem John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	13%		
	Priority 1		21%	28%
	Priority 1 & 2		26%	36%
Productivity	Baseline	23%		
	Priority 1		28%	36%
	Priority 1 & 2		29%	42%
Diversity index	Baseline	23%		
	Priority 1		40%	50%
	Priority 1 & 2		55%	66%

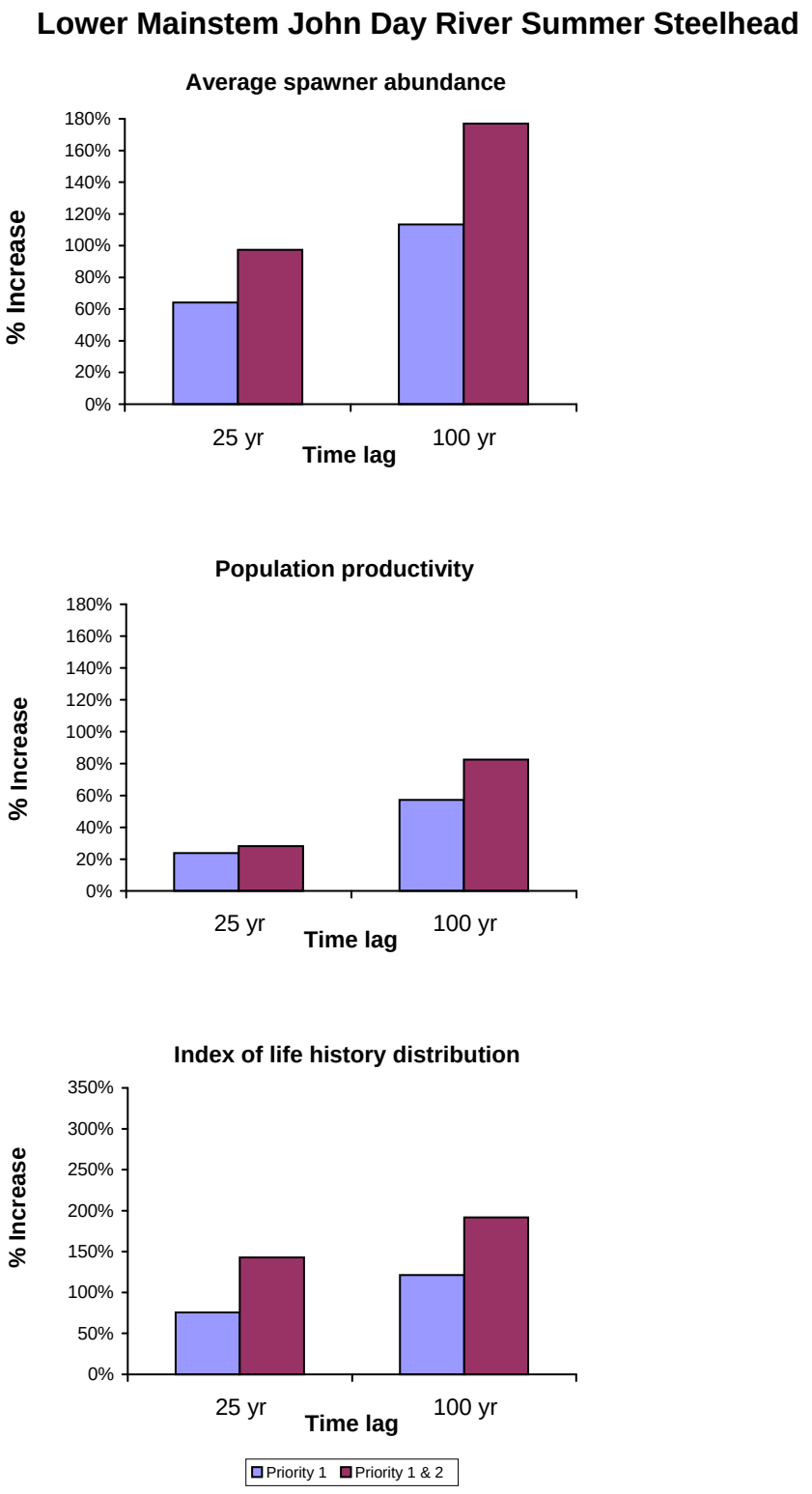


Figure 10-17. Estimated percent changes in population performance of Lower Mainstem John Day River summer steelhead due to tributary habitat actions.

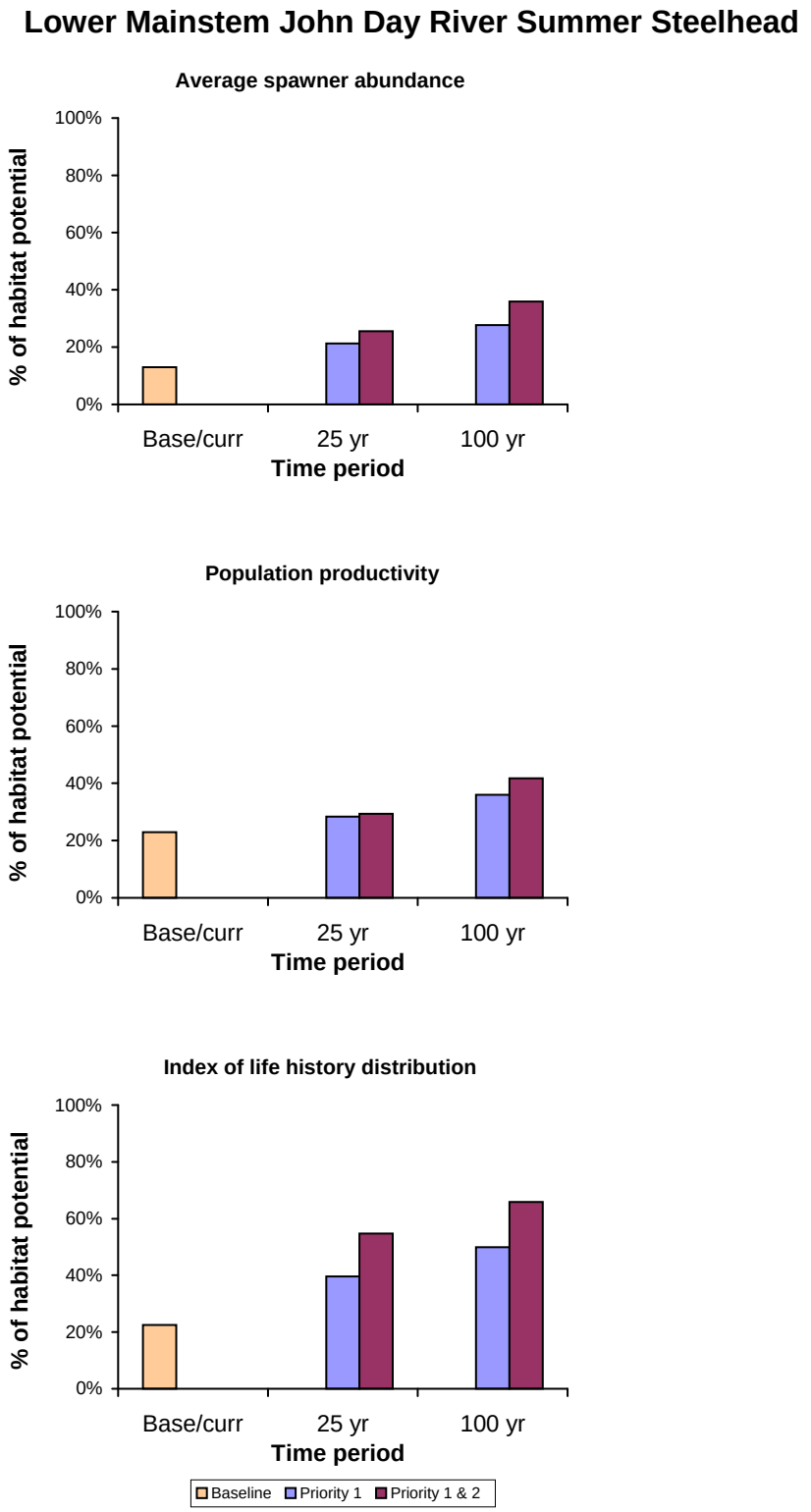


Figure 10-18. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Lower Mainstem John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

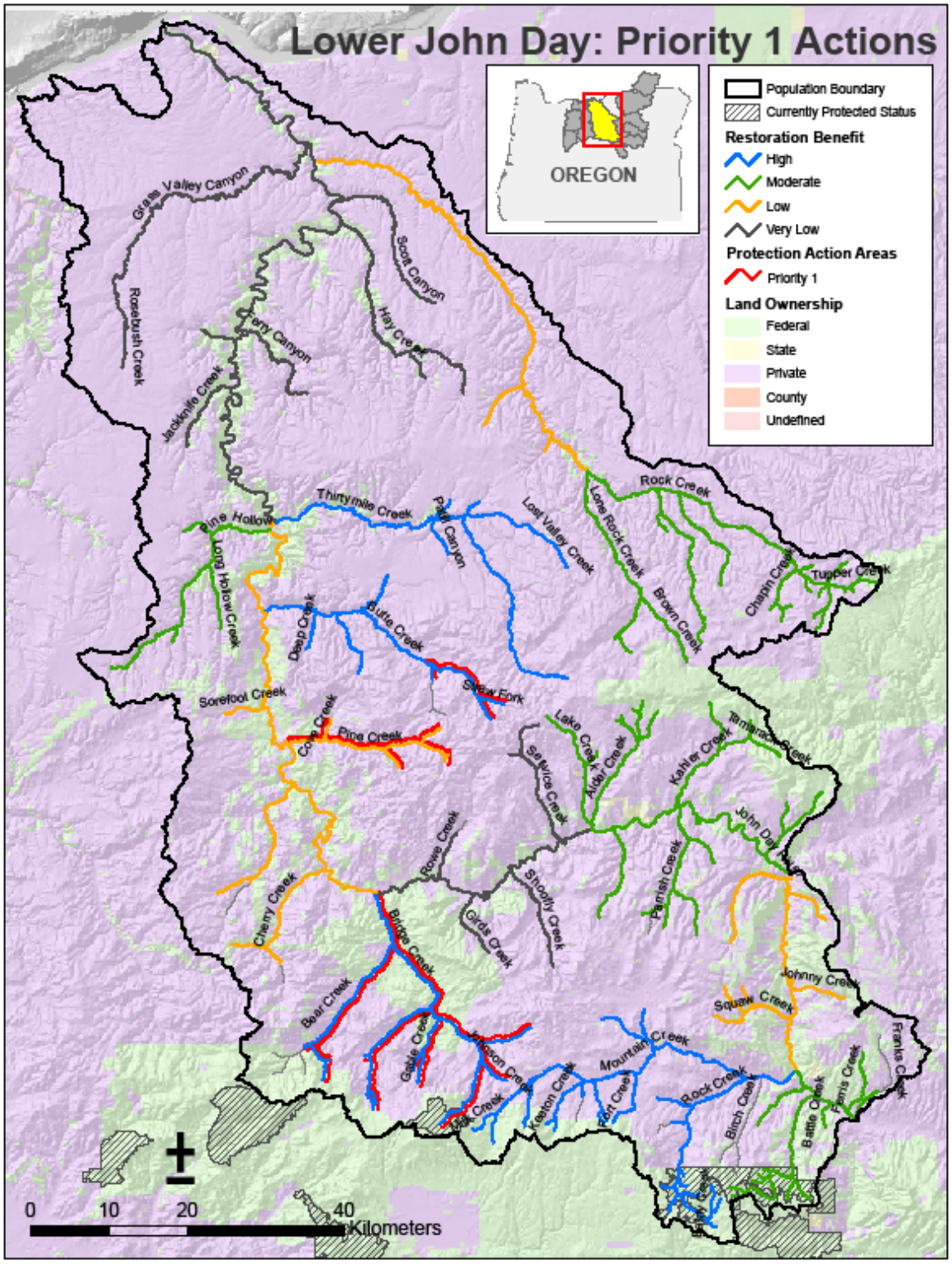


Figure 10-19. Map of the Lower Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

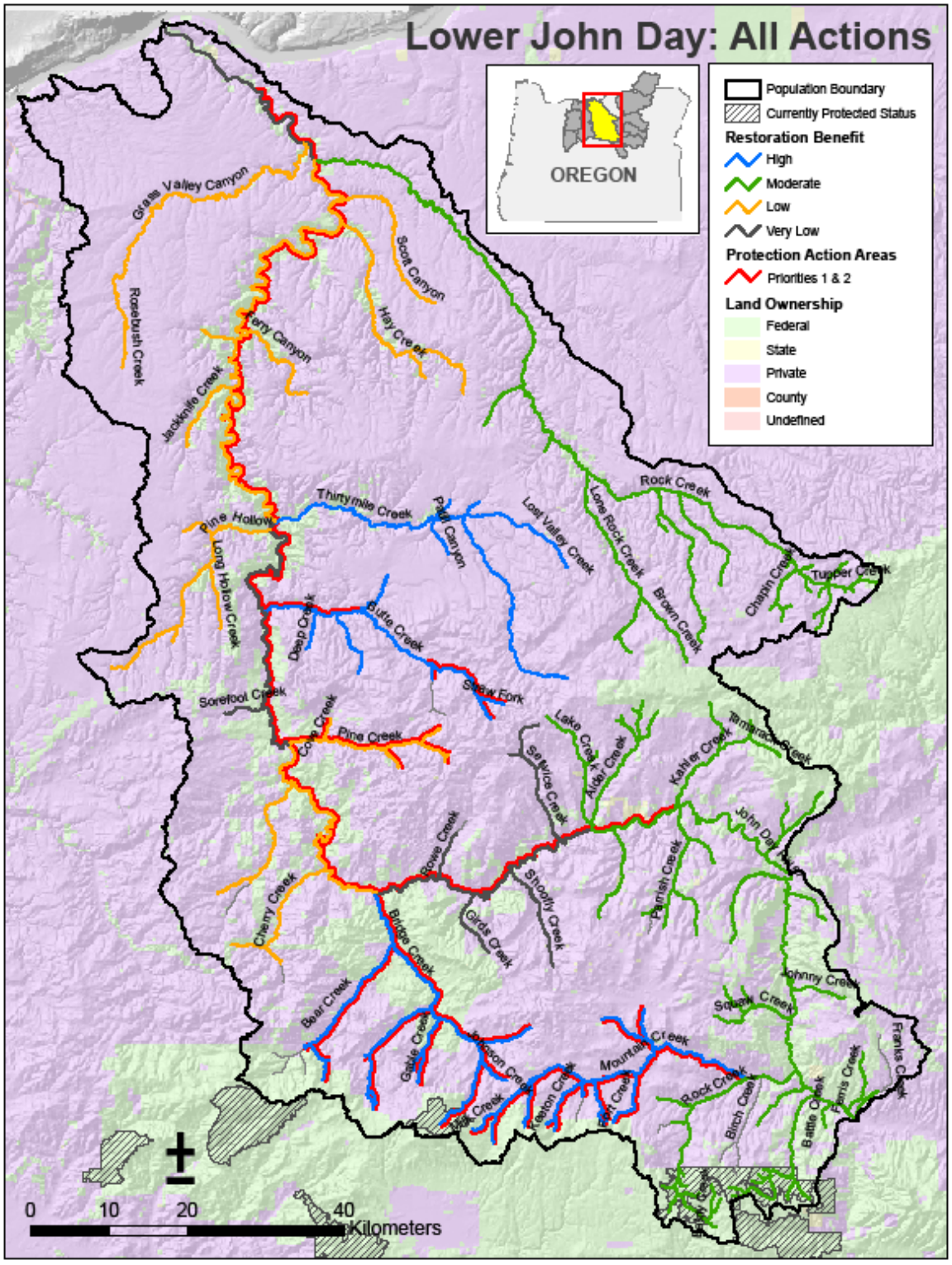


Figure 10-20. Map of the Lower Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.5 North Fork John Day River Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the North Fork John Day River population is least in the range of coverages applied to the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are in the range of 5-6 for Priority 1 and Priority 1 & 2 scenarios. One reason for low coverage in this geographic area is due to the presence of the North Fork Wilderness Area. The adjusted weighted average action effectiveness values also show that actual treated areas well less than values suggested by these ratios. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-18 summarizes tributary habitat action coverage and average action effectiveness values applied to the North Fork John Day River summer steelhead population.

Table 10-18. Summary of tributary habitat action coverage and average action effectiveness values applied to the North Fork John Day River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire John Day subbasin.

Population:	North Fork John Day River	
Total stream miles in John Day subbasin:	2,936	
	Priority 1	Priority 1 & 2
No. of North Fork John Day actions:	38	38
Total stream miles in North Fork John Day:	942	942
Cum miles affected by NFJD actions:	4,881	5,401
Ratio cum miles affected to total NFJD miles:	5.2	5.7
Weighted ave potential action effectiveness 1/:	0.145	0.146
Weighted ave adjusted action effectiveness 1/:	0.034	0.032

1/ Value shown is for entire John Day subbasin; weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of North Fork John Day River summer steelhead from tributary actions are shown in tables 10-19 and 10-20, and figures 10-21 and 10-22. Estimated increases in population performance resulting from tributary habitat actions are relatively moderate for this population (Figure 10-21). Amounts of habitat potential for the abundance and productivity performance measures reach approximately 45-55%. Amounts of

potential for the baseline for these performance measures are approximately 35-40% (Figure 10-22).

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-19. Estimated percent changes in population performance of North Fork John Day River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	23%	39%
	Priority 1 & 2	26%	44%
Productivity	Priority 1	15%	29%
	Priority 1 & 2	18%	35%
Diversity index	Priority 1	20%	32%
	Priority 1 & 2	23%	35%

Table 10-20. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to North Fork John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	36%		
	Priority 1		44%	50%
	Priority 1 & 2		45%	52%
Productivity	Baseline	39%		
	Priority 1		45%	50%
	Priority 1 & 2		46%	53%
Diversity index	Baseline	66%		
	Priority 1		79%	87%
	Priority 1 & 2		81%	89%

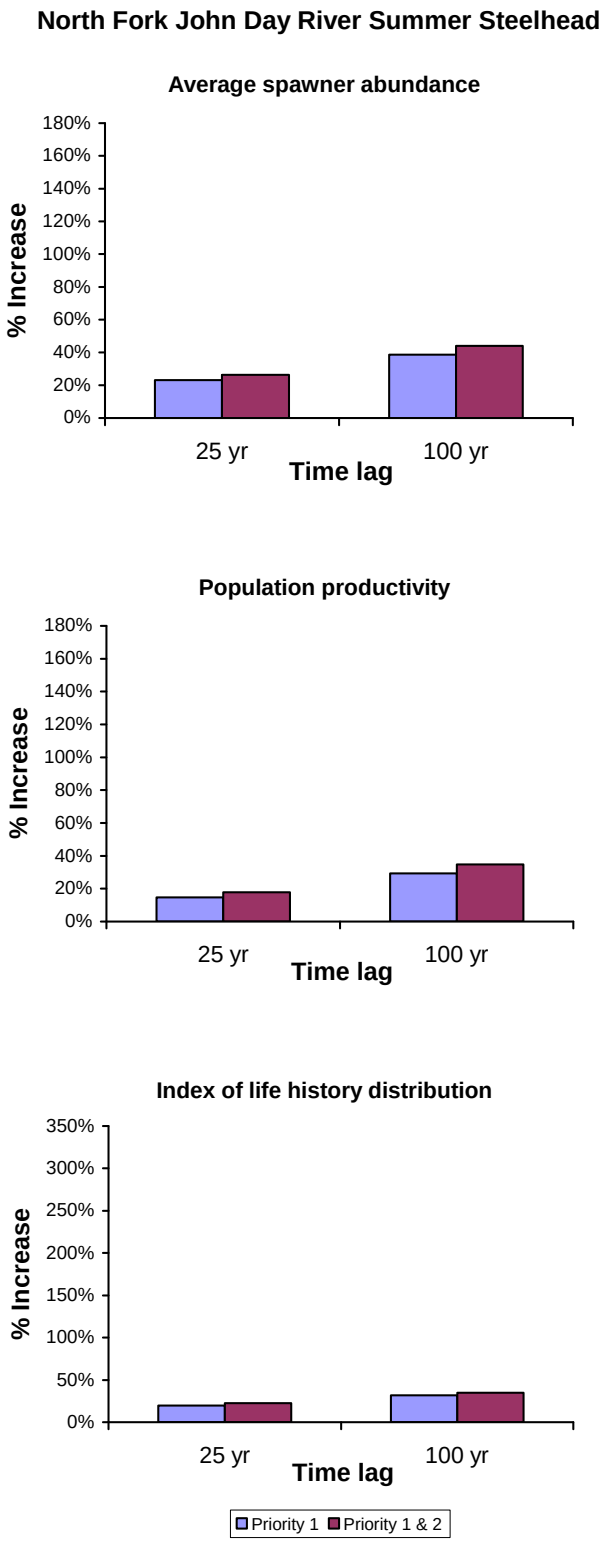


Figure 10-21. Estimated percent changes in population performance of North Fork John Day River summer steelhead due to tributary habitat actions.

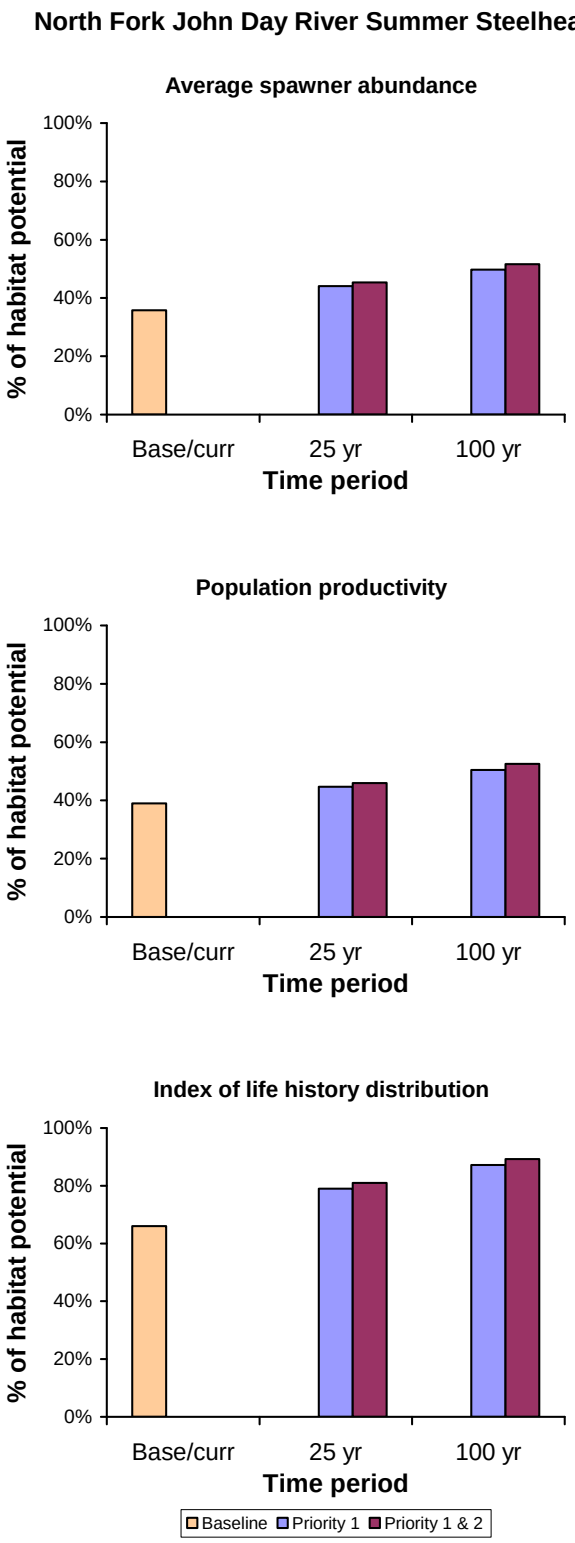


Figure 10-22. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to North Fork John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

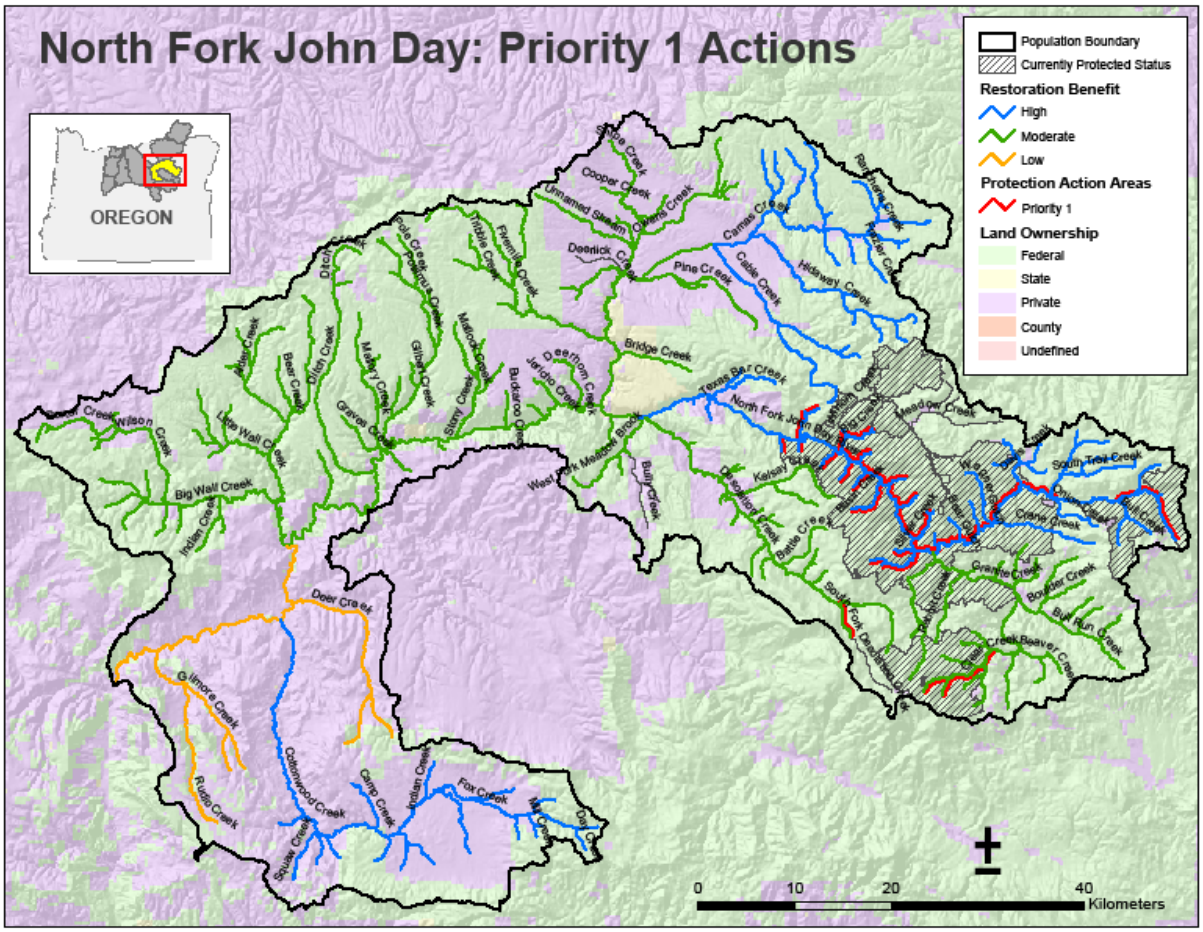


Figure 10-23. Map of the North Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

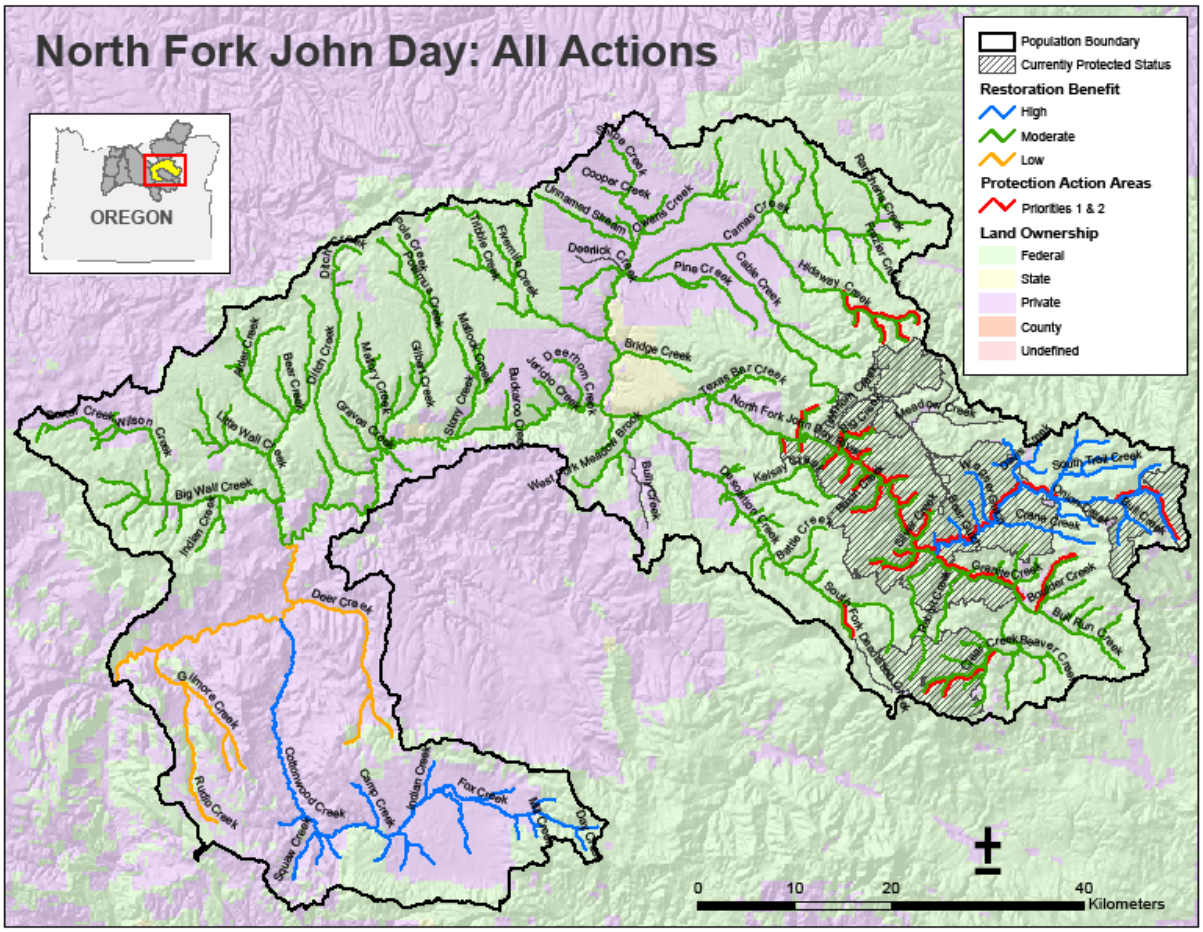


Figure 10-24. Map of the North Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.6 Middle Fork John Day River Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the Middle Fork John Day River population is on the lower end of the range of coverages applied to the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are in the range of 7-9 for Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-21 summarizes tributary habitat action coverage and average action effectiveness values applied to the Middle Fork John Day River summer steelhead population.

Table 10-21. Summary of tributary habitat action coverage and average action effectiveness values applied to the Middle Fork John Day River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire John Day subbasin.

Population:	Middle Fork John Day River	
Total stream miles in John Day subbasin:	2,936	
	Priority 1	Priority 1 & 2
No. of Middle Fork John Day actions:	36	36
Total stream miles in Middle Fork John Day:	380	380
Cum miles affected by MFJD actions:	2,806	3,441
Ratio cum miles affected to total MFJD miles:	7.4	9.1
Weighted ave potential action effectiveness 1/:	0.145	0.146
Weighted ave adjusted action effectiveness 1/:	0.034	0.032

1/ Value shown is for entire John Day subbasin; weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Middle Fork John Day River summer steelhead due to tributary actions are shown in tables 10-22 and 10-23, and in figures 10-25 and 10-26. Estimated increases in population performance resulting from tributary habitat actions are relatively moderate for this population (Figure 10-25). Amounts of habitat potential for the abundance and productivity performance measures with actions reach approximately 40-55%.

Amounts of potential for the baseline for these performance measures are approximately 30-35% (Figure 10-26).

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-22. Estimated percent changes in population performance of Middle Fork John Day River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	33%	57%
	Priority 1 & 2	40%	67%
Productivity	Priority 1	34%	65%
	Priority 1 & 2	40%	75%
Diversity index	Priority 1	19%	25%
	Priority 1 & 2	24%	31%

Table 10-23. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Middle Fork John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	32%		
	Priority 1		42%	50%
	Priority 1 & 2		44%	53%
Productivity	Baseline	33%		
	Priority 1		44%	54%
	Priority 1 & 2		46%	57%
Diversity index	Baseline	72%		
	Priority 1		86%	90%
	Priority 1 & 2		90%	94%

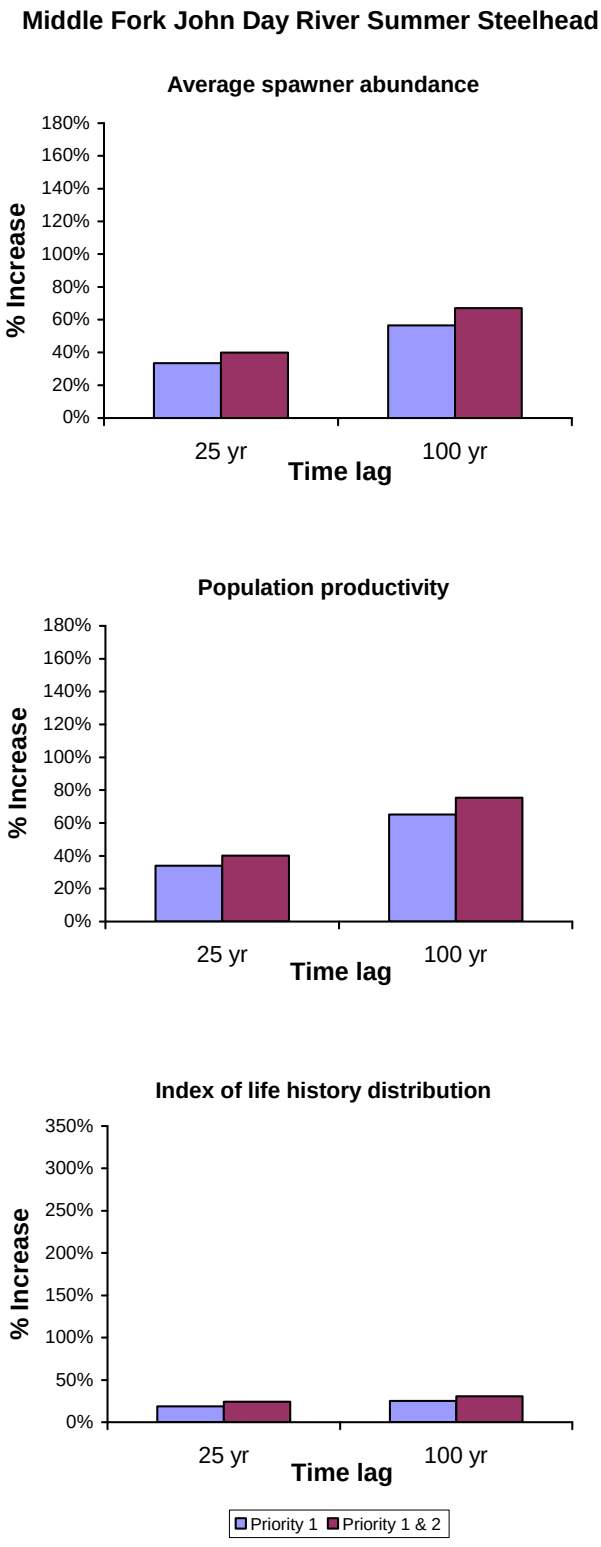


Figure 10-25. Estimated percent changes in population performance of Middle Fork John Day River summer steelhead due to tributary habitat actions.



Figure 10-26. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Middle Fork John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

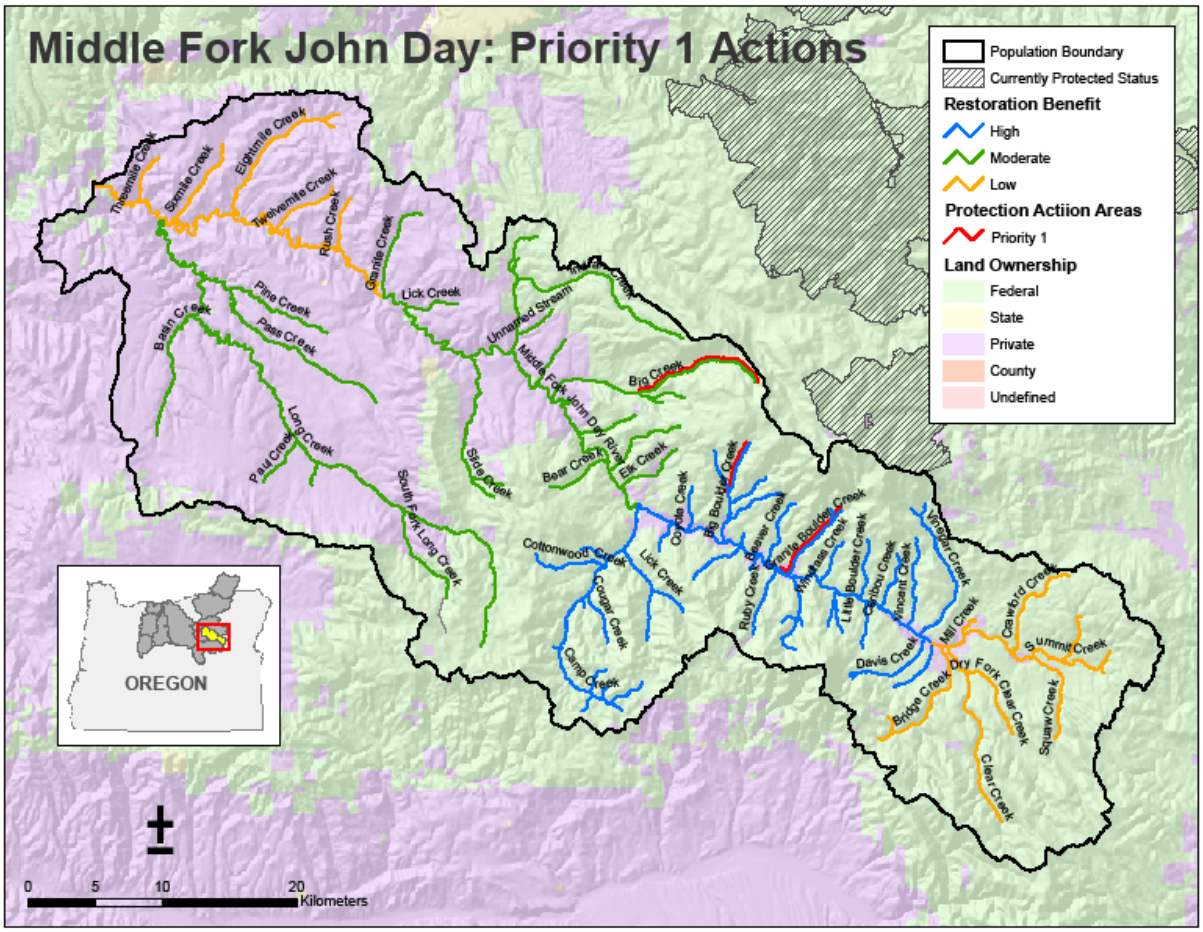


Figure 10-27. Map of the Middle Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

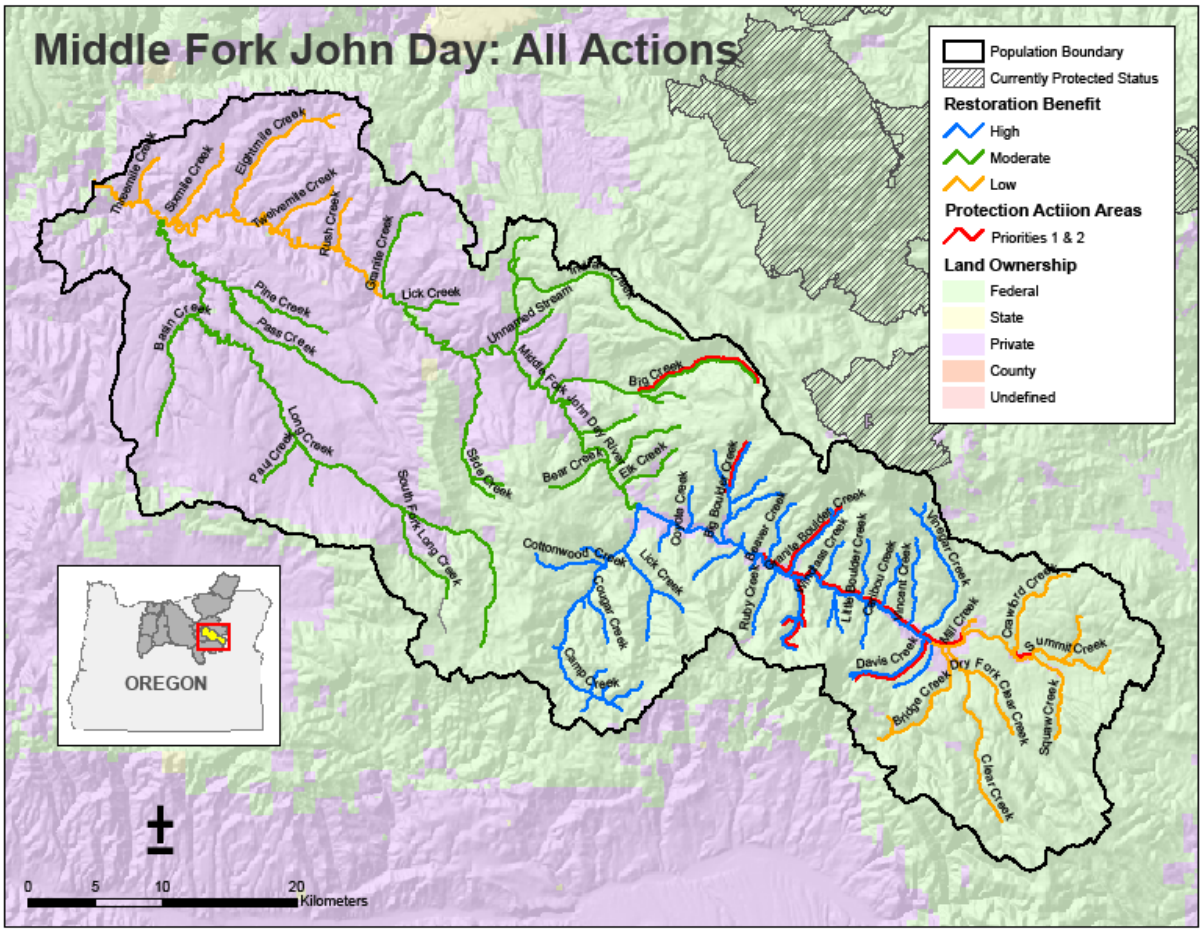


Figure 10-28. Map of the Middle Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.7 South Fork John Day River Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the South Fork John Day River population is on the lower end of the range of coverages applied to the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are in the range of 7-9 for Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-24 summarizes tributary habitat action coverage and average action effectiveness values applied to the South Fork John Day River summer steelhead population.

Table 10-24. Summary of tributary habitat action coverage and average action effectiveness values applied to the South Fork John Day River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire John Day subbasin.

Population:	South Fork John Day River	
Total stream miles in John Day subbasin:	2,936	
	Priority 1	Priority 1 & 2
No. of South Fork John Day actions:	36	36
Total stream miles in South Fork John Day:	173	173
Cum miles affected by SFJD actions:	1,211	1,468
Ratio cum miles affected to total SFJD miles:	7.0	8.5
Weighted ave potential action effectiveness 1/:	0.145	0.146
Weighted ave adjusted action effectiveness 1/:	0.034	0.032

1/ Value shown is for entire John Day subbasin; weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of South Fork John Day River summer steelhead from tributary actions are shown in tables 10-25 and 10-26, and figures 10-29 and 10-30. Estimated increases in population performance resulting from tributary habitat actions are relatively small to moderate for this population (Figure 10-29), depending on performance measure. Amounts of habitat potential for the abundance and productivity performance measures with actions reach approximately 40-55%. Amounts of potential for the baseline for these

performance measures are approximately 30-35% (Figure 10-30). Small increases were projected for the life history diversity metric.

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-25. Estimated percent changes in population performance of South Fork John Day River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	19%	35%
	Priority 1 & 2	26%	45%
Productivity	Priority 1	16%	32%
	Priority 1 & 2	21%	45%
Diversity index	Priority 1	14%	21%
	Priority 1 & 2	18%	23%

Table 10-26. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to South Fork John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	42%		
	Priority 1		50%	57%
	Priority 1 & 2		53%	61%
Productivity	Baseline	37%		
	Priority 1		43%	49%
	Priority 1 & 2		45%	53%
Diversity index	Baseline	79%		
	Priority 1		90%	96%
	Priority 1 & 2		93%	97%



Figure 10-29. Estimated percent changes in population performance of South Fork John Day River summer steelhead due to tributary habitat actions.

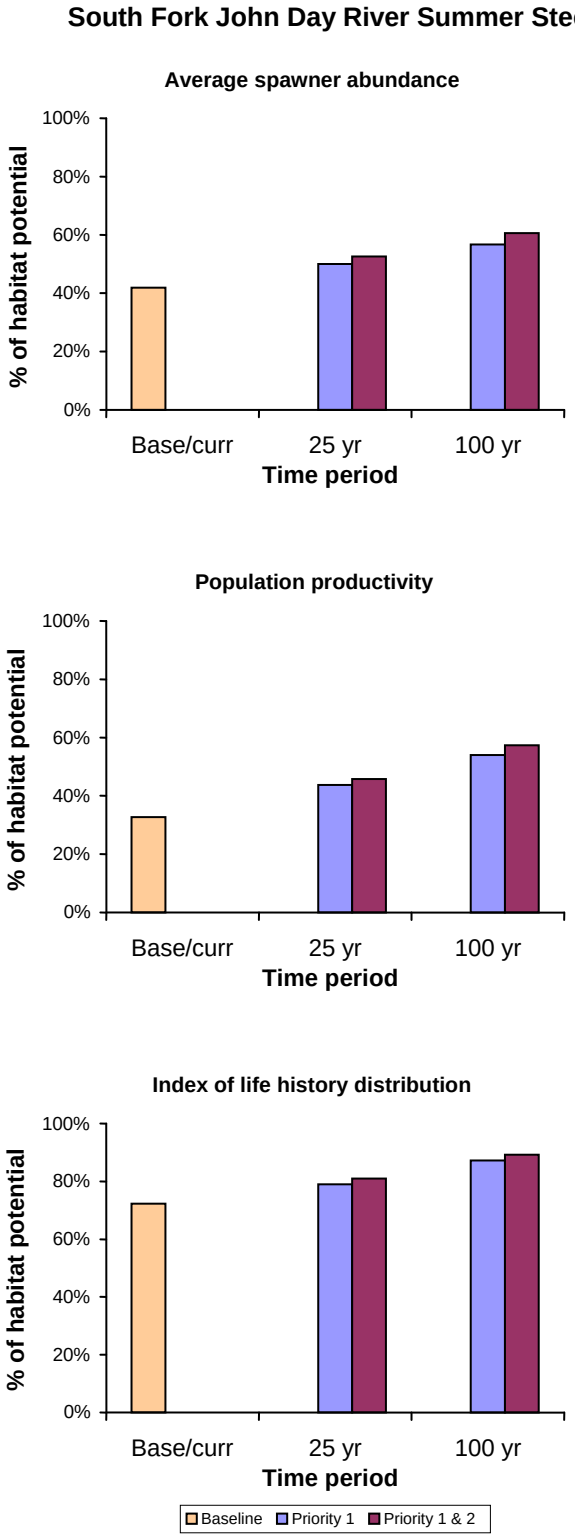


Figure 10-30. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to South Fork John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

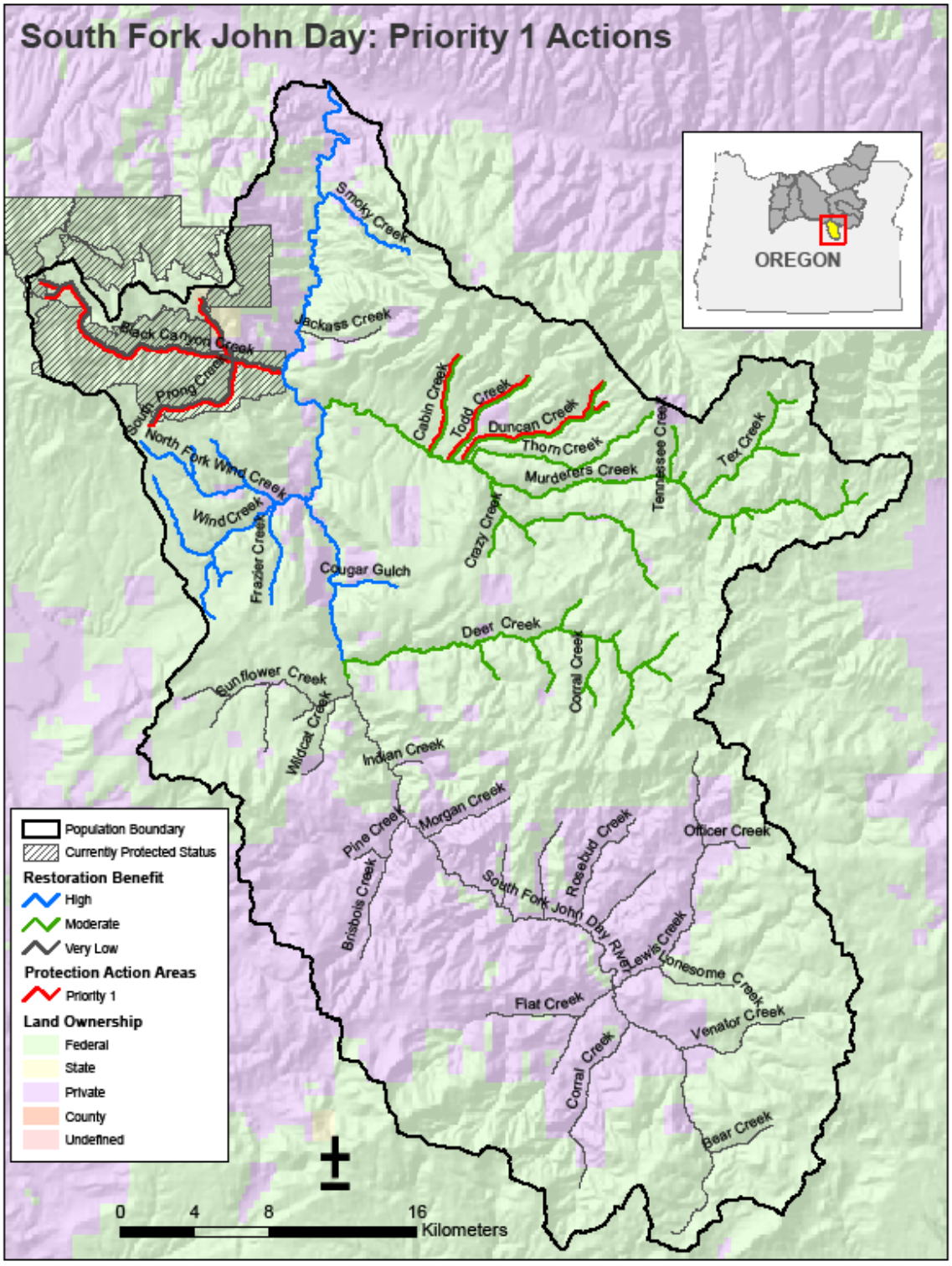


Figure 10-31. Map of the South Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

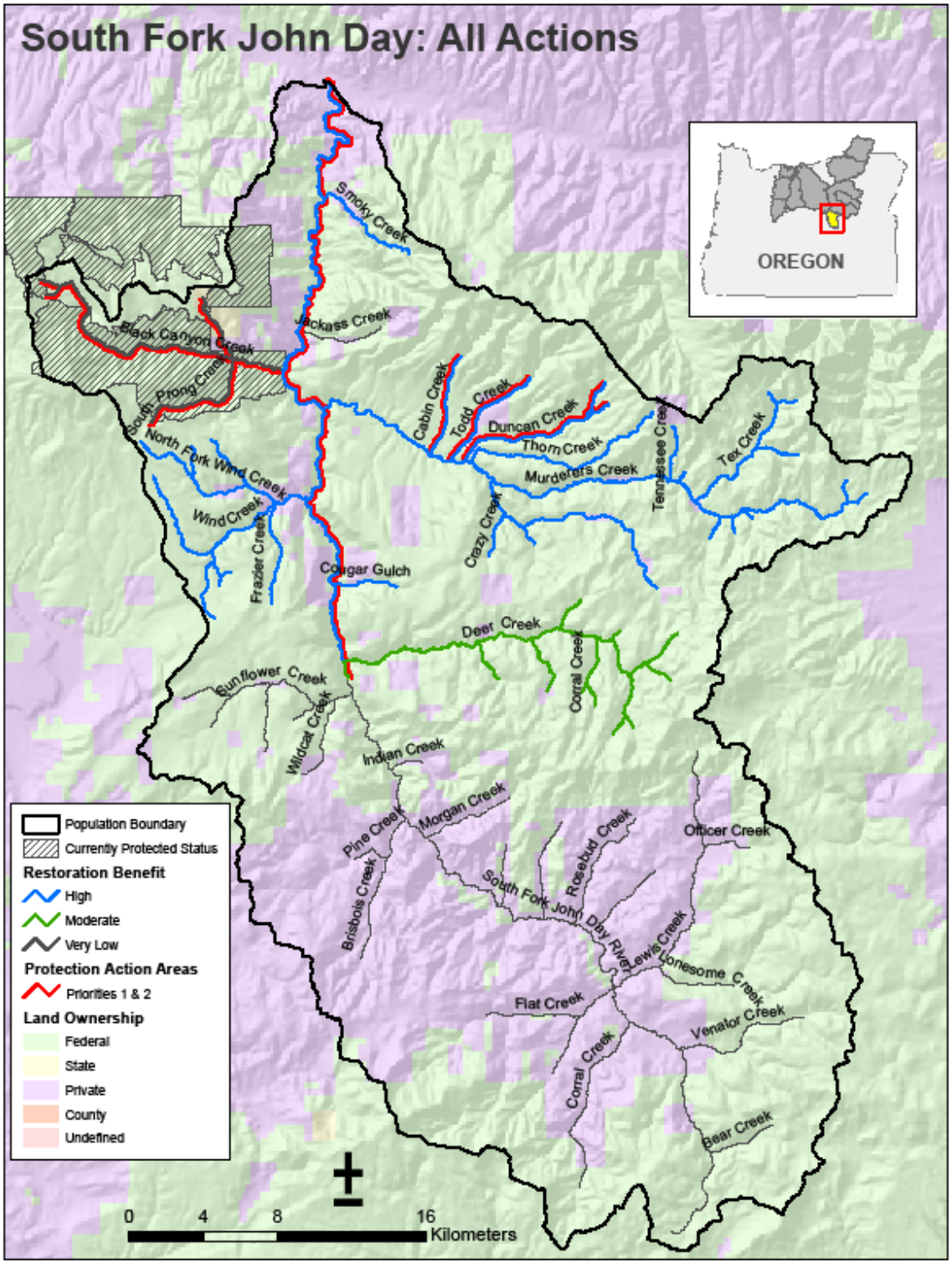


Figure 10-32. Map of the South Fork John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.8 Upper Mainstem John Day River Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the Upper Mainstem John Day River population is on the lower end of the range of coverages applied to the other Mid-Columbia Oregon steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are in the range of 7-10 for Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-27 summarizes tributary habitat action coverage and average action effectiveness values applied to the Upper Mainstem John Day River summer steelhead population.

Table 10-27. Summary of tributary habitat action coverage and average action effectiveness values applied to the Upper Mainstem John Day River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar. Effectiveness values shown apply to the entire John Day subbasin.

Population:	Upper Mainstem John Day River	
Total stream miles in John Day subbasin:	2,936	
	Priority 1	Priority 1 & 2
No. of Upper John Day actions:	36	36
Total stream miles in Upper John Day:	415	415
Cum miles affected by UpJD actions:	3,064	4,032
Ratio cum miles affected to total UpJD miles:	7.4	9.7
Weighted ave potential action effectiveness 1/:	0.145	0.146
Weighted ave adjusted action effectiveness 1/:	0.034	0.032

1/ Value shown is for all actions in the John Day subbasin; weighted by miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Upper Mainstem John Day River summer steelhead from tributary actions are shown in tables 10-28 and 10-29, and figures 10-33 and 10-34. Estimated increases in population performance resulting from tributary habitat actions are relatively moderate to large, depending on the performance measure (Figure 10-33). With these increases, performance for both productivity and abundance achieve only approximately 35-55% of habitat potential (Figure 10-34).

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-28. Estimated percent changes in population performance of Upper Mainstem John Day River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	37%	61%
	Priority 1 & 2	74%	110%
Productivity	Priority 1	23%	46%
	Priority 1 & 2	51%	92%
Diversity index	Priority 1	38%	51%
	Priority 1 & 2	89%	94%

Table 10-29. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Upper Mainstem John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	24%		
	Priority 1		33%	39%
	Priority 1 & 2		42%	51%
Productivity	Baseline	27%		
	Priority 1		34%	40%
	Priority 1 & 2		42%	53%
Diversity index	Baseline	44%		
	Priority 1		61%	66%
	Priority 1 & 2		83%	85%



Figure 10-33. Estimated percent changes in population performance of Upper Mainstem John Day River summer steelhead due to tributary habitat actions.



Figure 10-34. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Upper Mainstem John Day River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

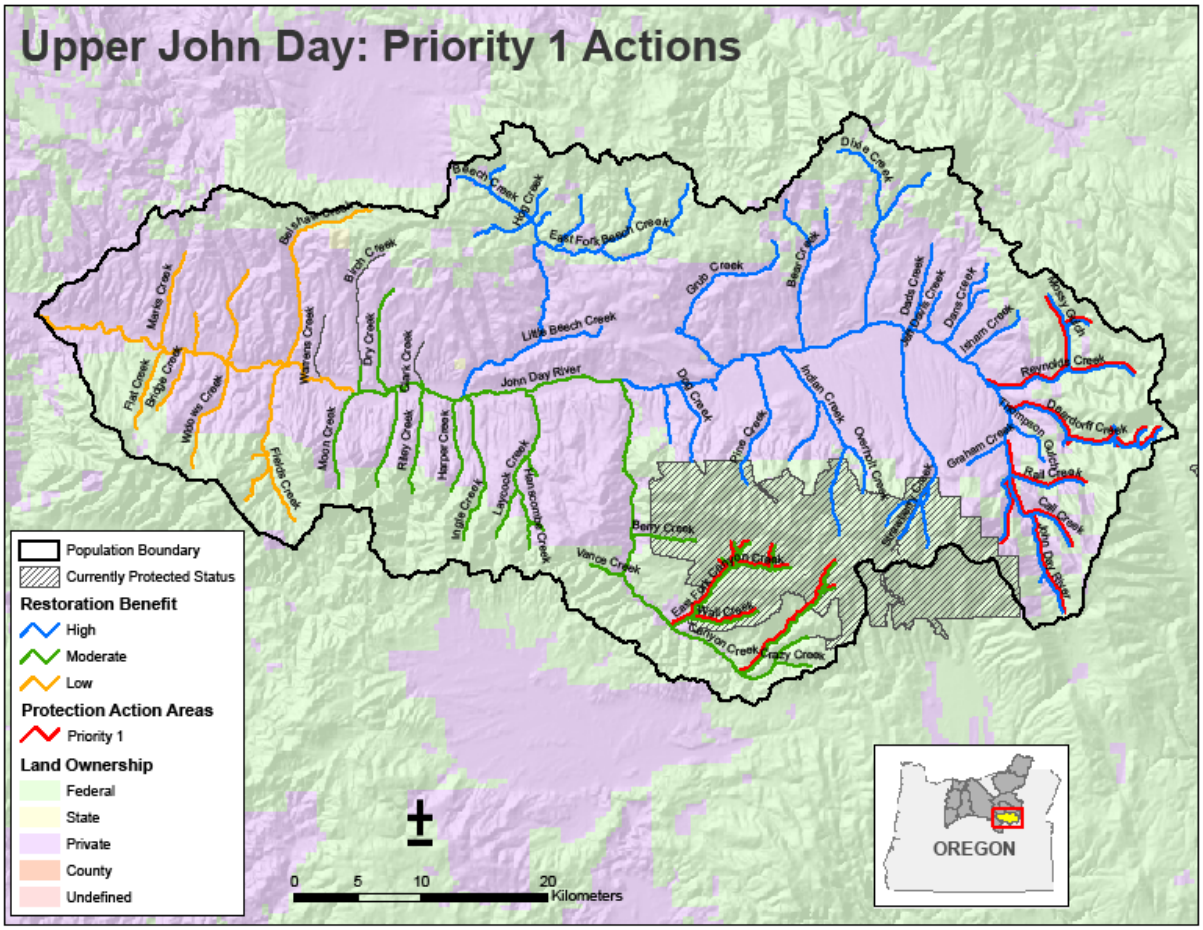


Figure 10-35. Map of the Upper Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

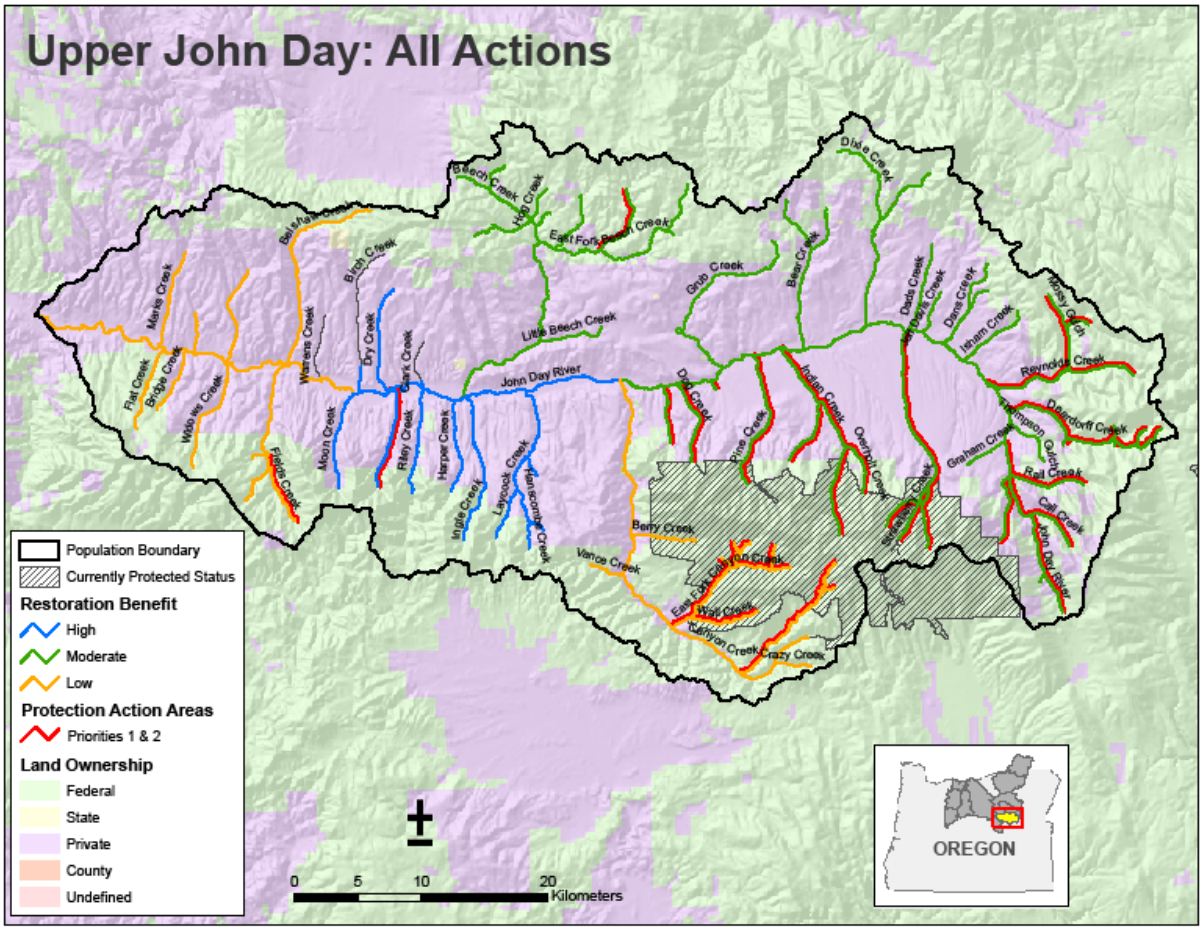


Figure 10-36. Map of the Upper Mainstem John Day River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.9 Umatilla River Summer Steelhead

Level of Action Coverage

The level of treatment coverage by habitat actions for the Umatilla River population is on the upper end of the range of coverages applied to the other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are in the range of 13-14 for Priority 1 and Priority 1 & 2 scenarios. The adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios, however. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River. Table 10-30 summarizes tributary habitat action coverage and average action effectiveness values applied to the Umatilla River summer steelhead population.

Table 10-30. Summary of tributary habitat action coverage and average action effectiveness values applied to the Umatilla River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar.

Population:	Umatilla River	
Total stream miles in subbasin:	681	
	Priority 1	Priority 1 & 2
No. of actions:	38	38
Cum miles affected by actions:	9,055	9,664
Ratio cum miles affected to total miles:	13.3	14.2
Weighted ave potential action effectiveness 1/:	0.255	0.247
Weighted ave adjusted action effectiveness 1/:	0.048	0.046

1/ Weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Umatilla River summer steelhead due to tributary habitat actions are shown in tables 10-31 and 10-32, and figures 10-37 and 10-38. Estimated increases in population performance resulting from tributary habitat actions are relatively moderate to large, depending on the performance measure (Figure 10-37). The increase in productivity is less for Priority 1 & 2 actions (i.e., all actions) compared to just Priority 1 actions. This is the result of a Priority 2 action opening habitat blocked by a barrier—habitat upstream of the barrier is relatively low in quality. The effect is that productivity is reduced while overall habitat capacity, hence spawner abundance, is increased (more habitat open to be used).

Between approximately 45-70% of habitat potential (i.e., historical potential) for abundance, productivity, and the life history diversity measure is estimated to be achieved for the four scenarios considered (Figure 10-38).

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-31. Estimated percent changes in population performance of Umatilla River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	67%	93%
	Priority 1 & 2	82%	112%
Productivity	Priority 1	71%	116%
	Priority 1 & 2	62%	101%
Diversity index	Priority 1	53%	72%
	Priority 1 & 2	61%	96%

Table 10-32. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Umatilla River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	28%		
	Priority 1		46%	53%
	Priority 1 & 2		51%	59%
Productivity	Baseline	28%		
	Priority 1		48%	61%
	Priority 1 & 2		46%	57%
Diversity index	Baseline	36%		
	Priority 1		56%	63%
	Priority 1 & 2		59%	71%

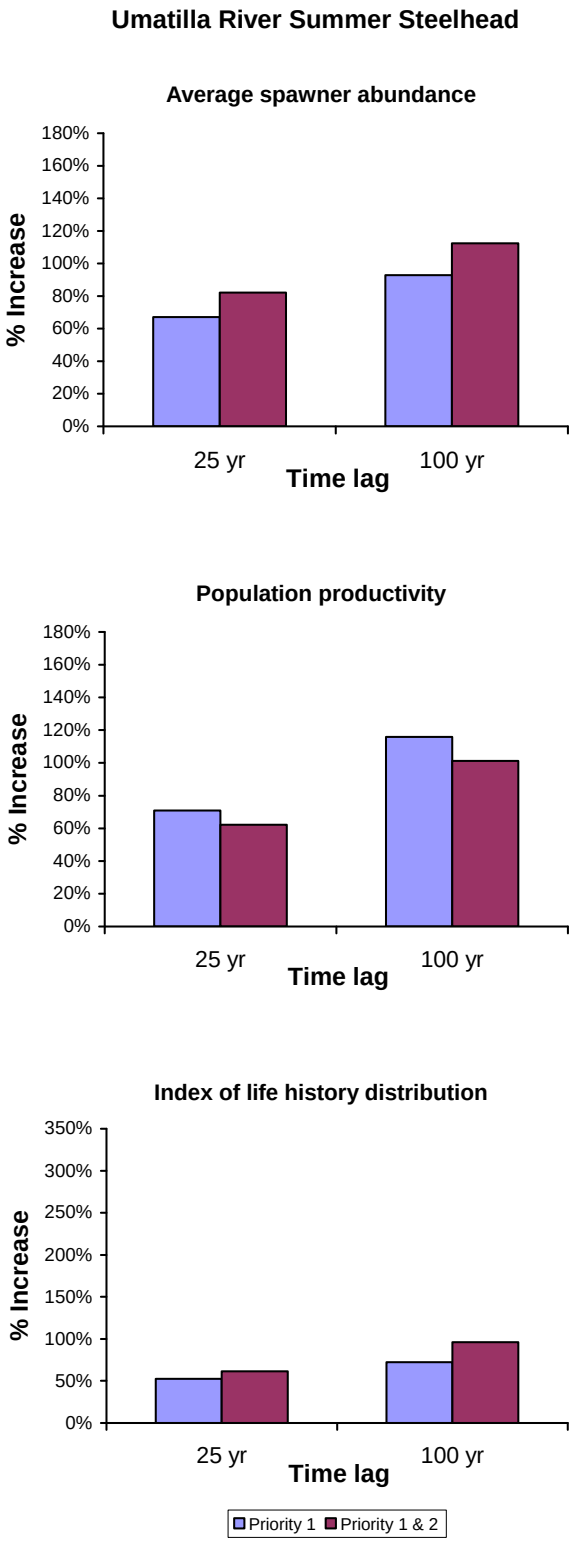


Figure 10-37. Estimated percent changes in population performance of Umatilla River summer steelhead due to tributary habitat actions.



Figure 10-38. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Umatilla River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

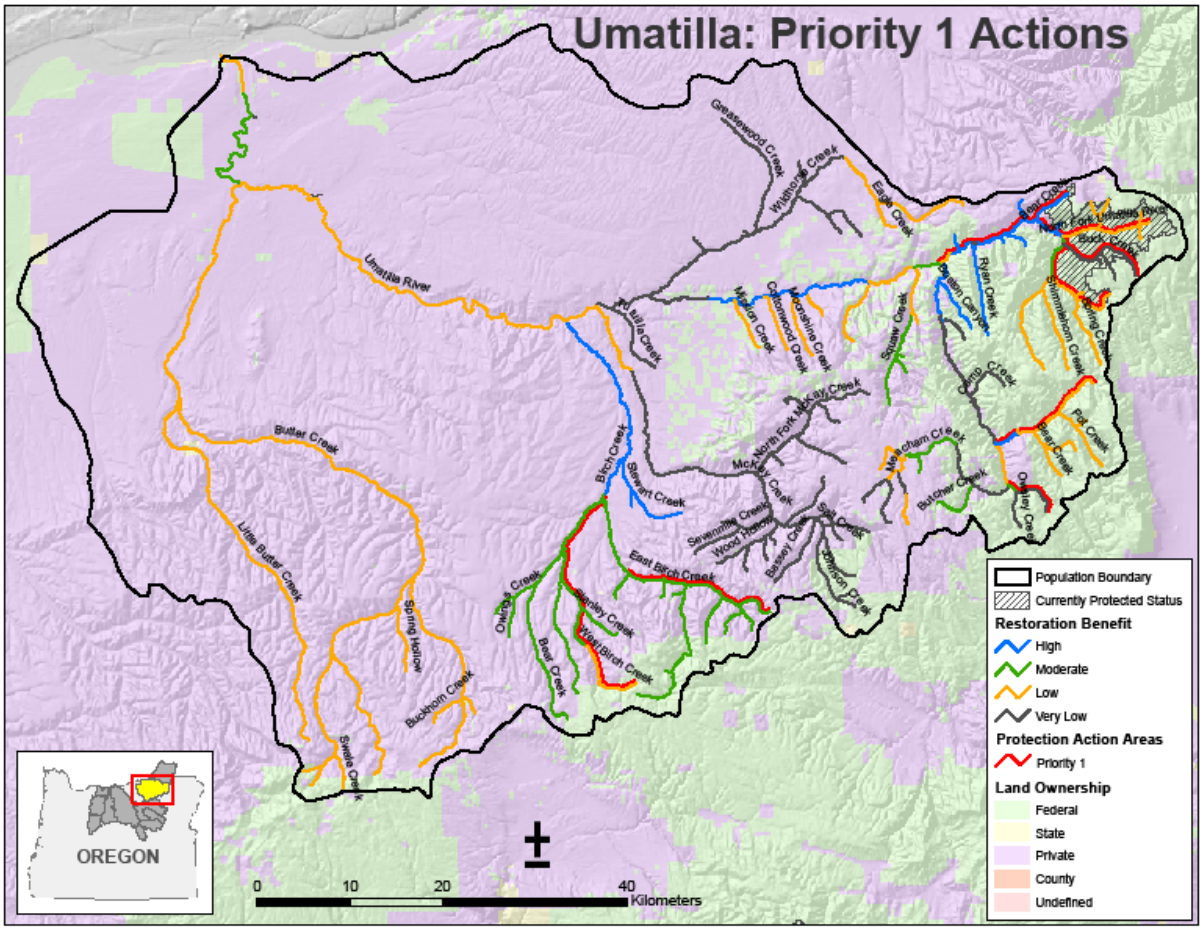


Figure 10-39. Map of the Umatilla River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

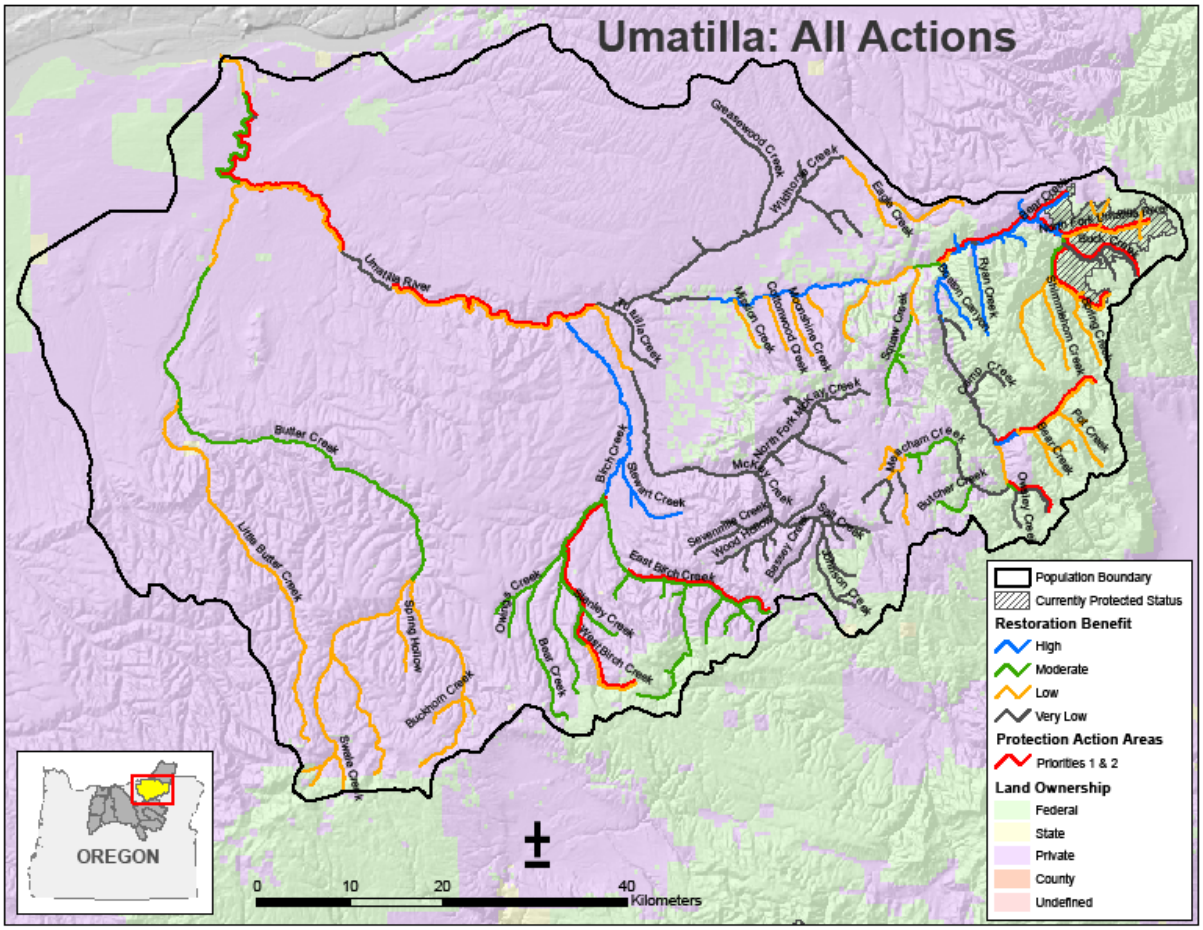


Figure 10-40. Map of the Umatilla River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.2.10 Walla Walla River Summer Steelhead

Level of Action Coverage

The number of actions applied in the analysis of the Walla Walla River population was substantially more than used to analyze any of the other Oregon Mid-C steelhead populations that were modeled. While the distribution of treatment for some of these actions was described in Section 9 as occurring within both Oregon and Washington, we modeled the actions as occurring only within Oregon. (Downstream effects of actions were still incorporated.) Table 10-33 summarizes tributary habitat action coverage and average action effectiveness values applied to the Walla Walla River summer steelhead population.

The level of treatment coverage by habitat actions applied to the Walla Walla River population is roughly in the middle of the range of coverages applied to other Oregon Mid-C steelhead populations. The ratios of cumulative miles potentially affected by actions to total stream miles available are in the range of 10-12 for Priority 1 and Priority 1 & 2 scenarios. However, the adjusted weighted average action effectiveness values show that actual treated areas would be far less than suggested by these ratios. The reader should note that the cumulative miles affected by the actions include stream miles outside the population's boundaries as defined by spawning distribution—encompassing miles within the migration corridor and downstream rearing areas down to the confluence of the subbasin with the mainstem Columbia River.

Table 10-33. Summary of tributary habitat action coverage and average action effectiveness values applied to the Walla Walla River summer steelhead population. Total stream miles are those modeled in EDT. Cumulative miles affected are the total miles targeted for actions without considering intensity of treatment by actions. Average potential and adjusted effectiveness values are weighted by stream miles targeted by each action. Average adjusted action effectiveness values incorporate all action scalars except the attribute scalar.

Population:	Walla Walla River	
Total stream miles in subbasin:	415	
	Priority 1	Priority 1 & 2
No. of actions:	53	53
Cum miles affected by actions:	4,434	4,789
Ratio cum miles affected to total miles:	10.7	11.5
Weighted ave potential action effectiveness 1/:	0.134	0.131
Weighted ave adjusted action effectiveness 1/:	0.047	0.043

1/ Weighted by stream miles affected per action

Projected Changes to Population Performance

Estimated percent changes in population performance of Walla Walla River summer steelhead due to tributary habitat actions are shown in tables 10-34 and 10-35, and figures 10-41 and 10-42. Results presented here reflect the result of actions applied only to waters within Oregon,

though effects to habitat characteristics continue downstream into Washington waters. Estimated increases in population performance resulting from tributary habitat actions are relatively moderate to large, depending on the performance measure (Figure 10-41).

Between approximately 40-60% of habitat potential (i.e., historical potential) for abundance and productivity is estimated to be achieved for the four scenarios considered (Figure 10-42). However, the amount of habitat potential expressed through life history diversity (i.e., distribution within the drainage) reaches only about 20%. This is apparently due to effects of barriers or poor quality conditions in reaches downstream of reaches in Oregon.

It should be noted that these measures of performance for this part of the analysis do not include any loss in performance that might be associated with genetic fitness loss due to strays.

Table 10-34. Estimated percent changes in population performance of Walla Walla River summer steelhead due to tributary habitat actions.

Performance measure	Scenario	Time period lag	
		25 yr	100 yr
Abundance	Priority 1	97%	119%
	Priority 1 & 2	99%	121%
Productivity	Priority 1	54%	70%
	Priority 1 & 2	54%	69%
Diversity index	Priority 1	82%	91%
	Priority 1 & 2	90%	112%

Table 10-35. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Walla Walla River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin. Performance for habitat potential is computed with baseline (i.e., post-development) out-of-subbasin conditions in place.

Performance measure	Scenario	Time period		
		Base/Curr	25 yr	100 yr
Abundance	Baseline	19%		
	Priority 1		38%	42%
	Priority 1 & 2		38%	42%
Productivity	Baseline	37%		
	Priority 1		57%	63%
	Priority 1 & 2		57%	63%
Diversity index	Baseline	12%		
	Priority 1		21%	22%
	Priority 1 & 2		22%	24%

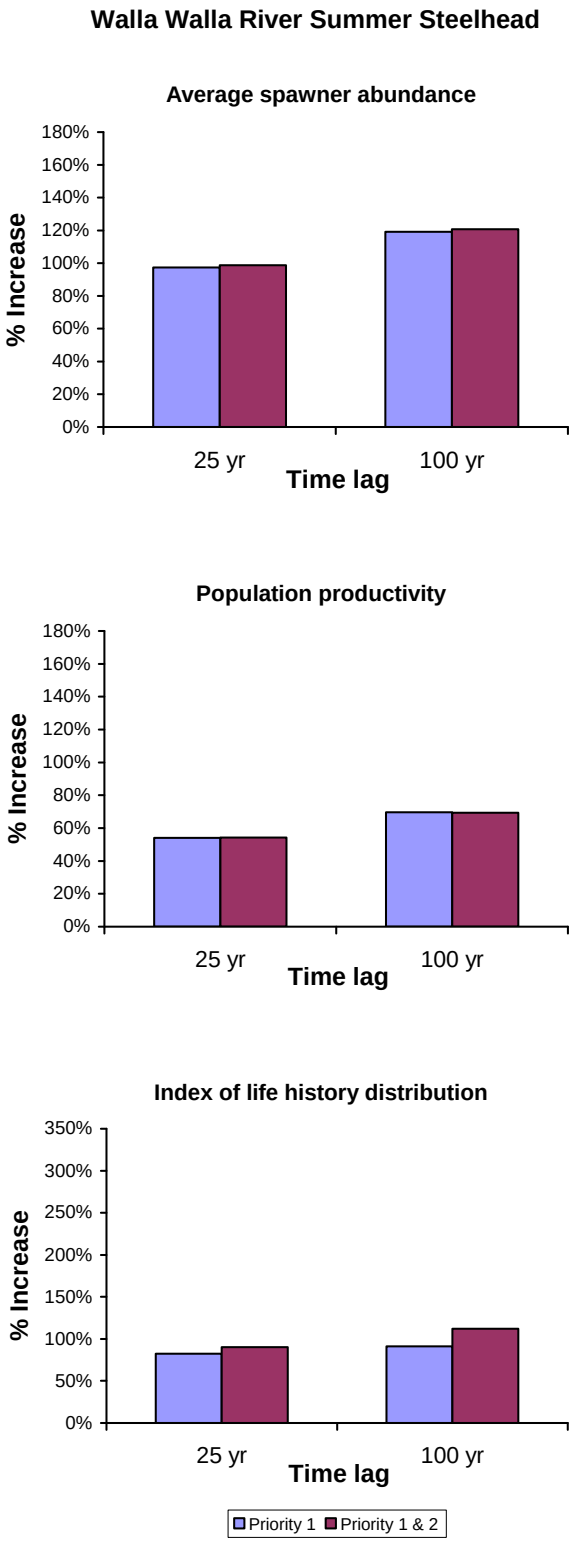


Figure 10-41. Estimated percent changes in population performance of Walla Walla River summer steelhead due to tributary habitat actions.

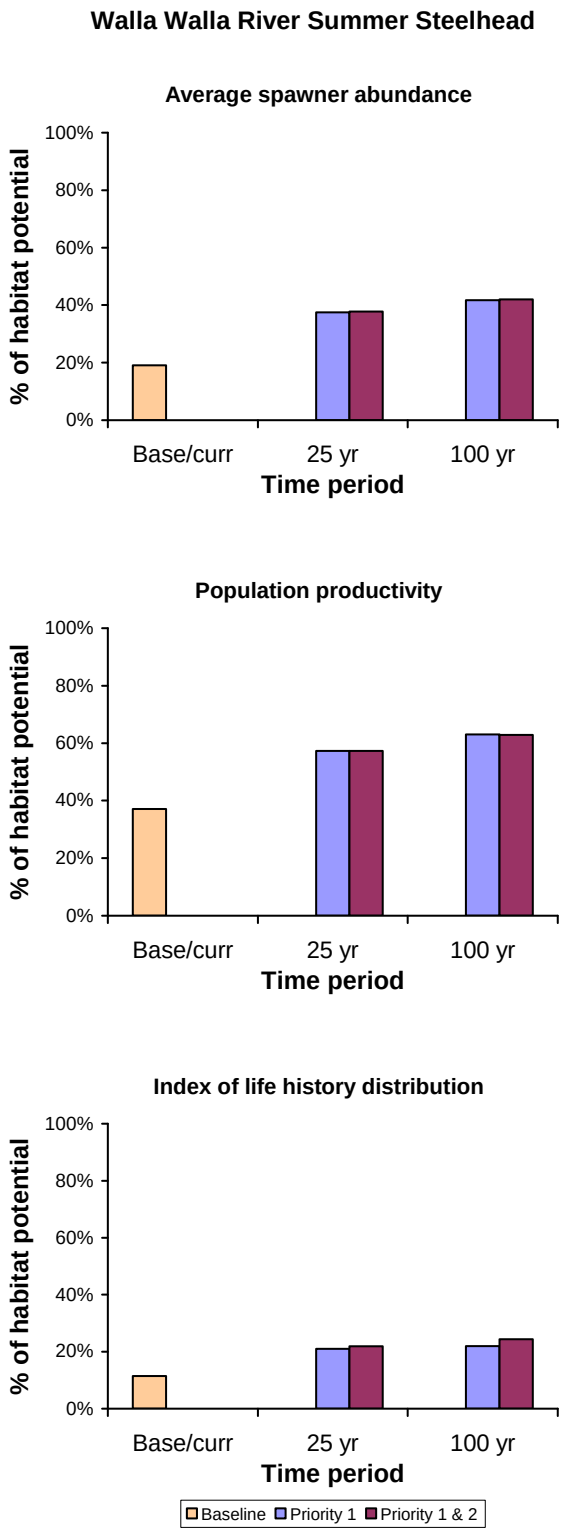


Figure 10-42. Estimated amounts of tributary habitat potential achieved by population performance measures resulting from tributary habitat actions applied to Walla Walla River summer steelhead. Habitat potential is assumed equal to performance associated with the pre-development condition in the subbasin.

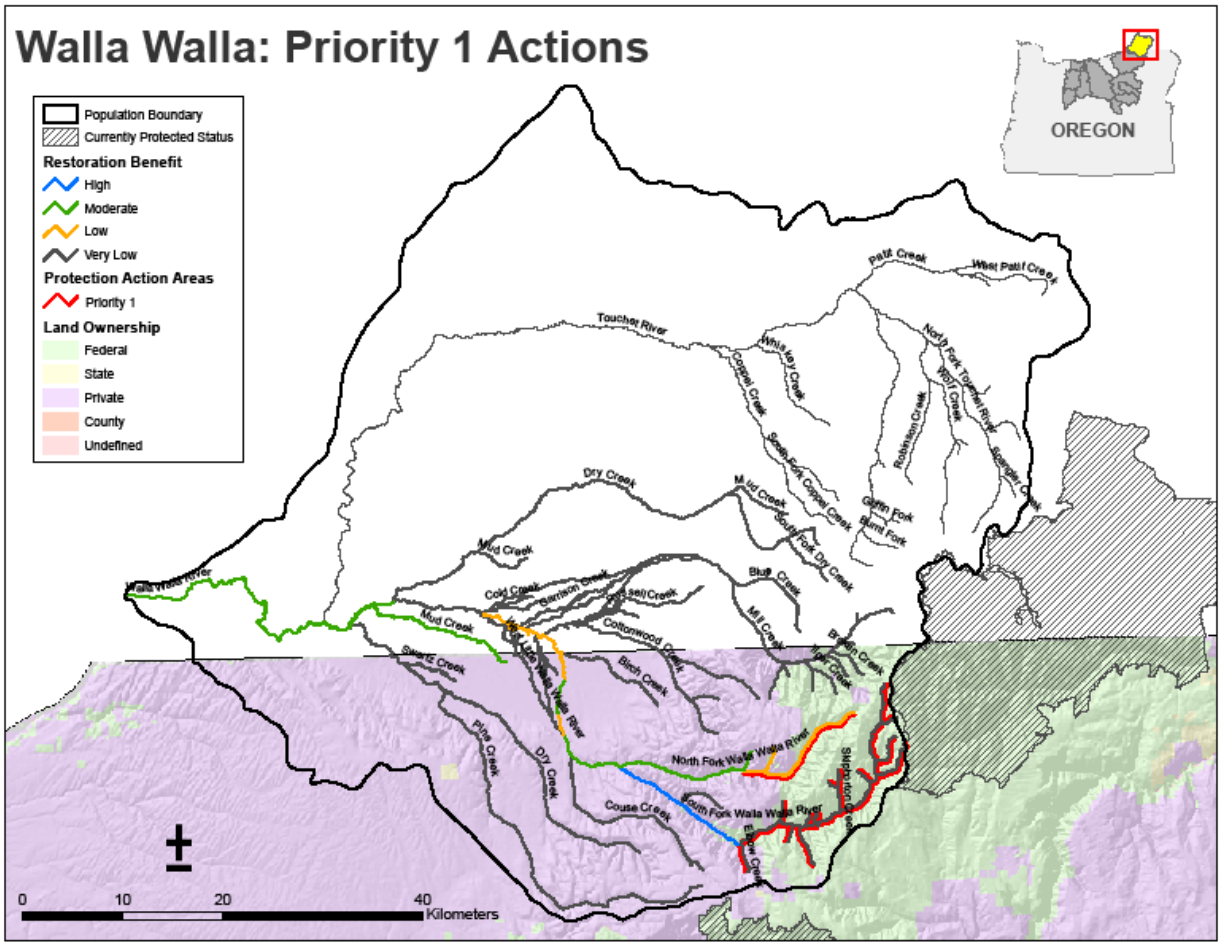


Figure 10-43. Map of the Walla Walla River steelhead population showing geographic areas that are currently in protected status, reaches identified as high priority for proposed protection management actions, and relative restoration benefit from high priority (priority 1) proposed restoration actions for all reaches.

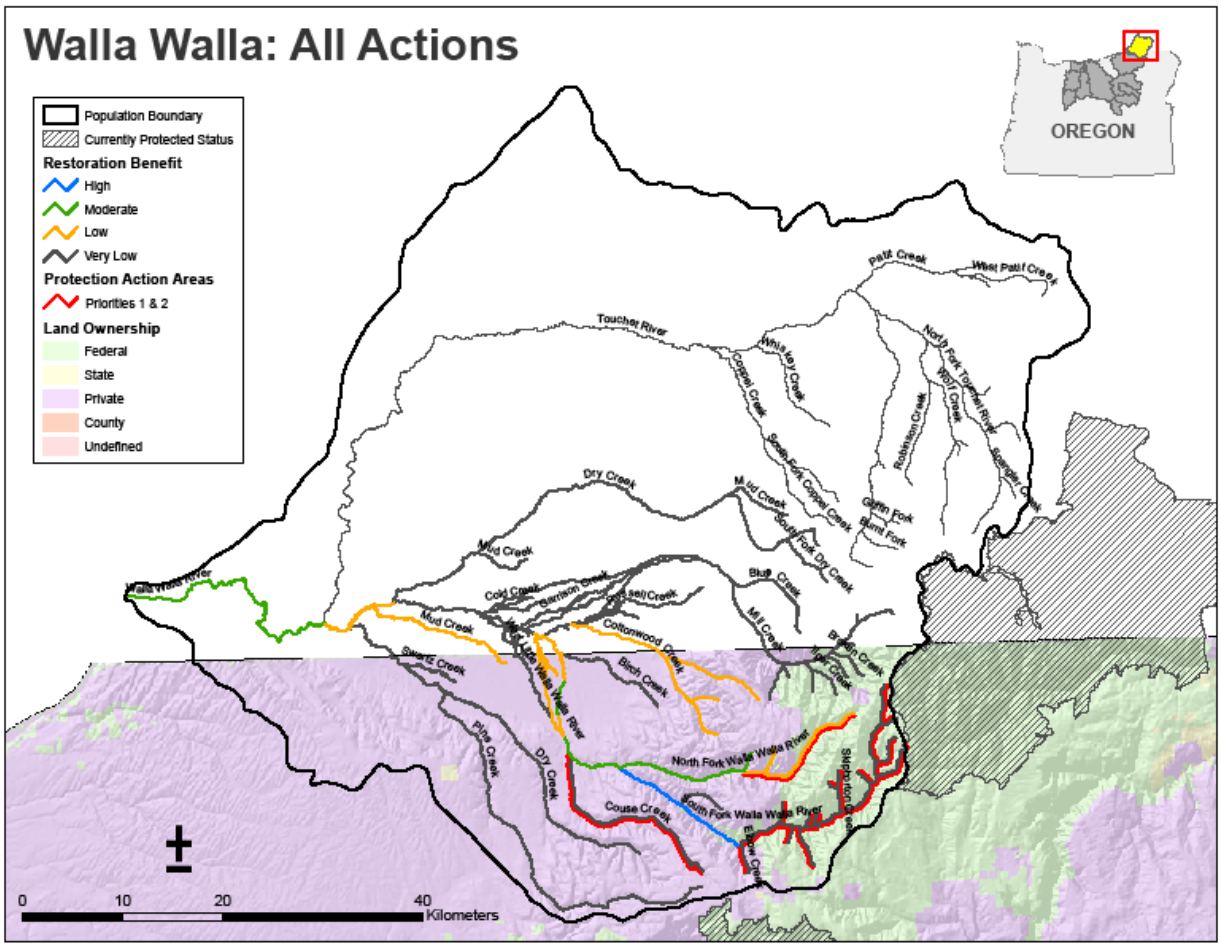


Figure 10-44. Map of the Walla Walla River steelhead population showing geographic areas that are currently in protected status, reaches identified for proposed protection management actions (priority 1 and priority 2), and reaches with high, moderate, low and very low restoration benefit from all (priority 1 and priority 2) proposed restoration actions.

10.3 All-H Integration Analysis

Results of All-H integration analysis are presented for each population below. Changes in performance measures associated with each action scenario are presented for intrinsic productivity and equilibrium spawner abundance, as these metrics were described earlier in this section. The results are comparable to population metrics presented in Section 6 for baseline performance, as derived empirically by the ICTRT, and to minimum productivity (at the threshold abundance level) and abundance viability thresholds at the 5% risk level (see Table 5-3 in Section 5). Thresholds represent one combination of abundance and productivity needed to achieve a 95% probability of persistence over 100 years. The threshold levels are specific to population size and are based on estimates of historical capacity.

Scenarios were run in a stepwise fashion, starting with baseline, then current condition, then adding in actions sequentially, each being added to the previous scenario. The effects of hatchery steelhead programs on genetic fitness—hence performance—of natural-origin fish were incorporated for each scenario using AHA.

To facilitate an understanding of how estimated performance levels compare to viability thresholds, we computed the ratio of scenario performance/viability threshold level for both abundance and productivity (referred to here as the threshold ratio). Values >1 indicate that performance is expected to achieve the viability threshold criterion for a 5% risk. The amount that the ratio exceeds 1 provides a relative measure of risk—with risk diminishing as the ratio increases. Ratio values <1 suggest a risk level >5%. Table 10-36 provides a list of abbreviations used in the tables and figures.

Table 10-36. Abbreviations used in tables reporting All-H integration results.

Area and abbreviation	Definition
Tributary	
B	Baseline condition
P1-25	Priority 1 actions at 25 yrs
P12-25	Priority 1 and 2 actions at 25 yrs
P1-100	Priority 1 actions at 100 yrs
P12-100	Priority 1 and 2 actions at 100 yrs
Mainstem and estuary	
B	Baseline condition
C	Current condition
Hyd	Hydro action
Pred	Predation plus hydro actions
Est	Estuarine, predation, hydro actions
Har	Harvest, Estuarine, predation, hydro actions
All	All actions (same as Har)
Ocean	
B/C	Baseline and current (assumed same)
-25%	75% of average marine survival
25%	125% of average marine survival

10.3.1 Fifteenmile Creek Winter Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. By far, the largest contribution to performance improvements is estimated to be due to tributary habitat actions. Relatively small increases are estimated to occur as a result of mainstem actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. Most scenario combinations result in threshold ratios >2, suggesting a very low risk of extinction over 100 years.

Estimated changes in population performance (productivity and equilibrium abundance) of Fifteenmile Creek winter steelhead associated with combinations of tributary and out-of-subbasin actions are shown in Table 10-37 and Figure 10-45.

Table 10-37. Estimated population performance (productivity and equilibrium abundance) of Fifteenmile Creek winter steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	1.82	703	1.16	1.41
B	C	B/C	1.96	764	1.25	1.53
P1-25	C	B/C	2.91	1,322	1.85	2.64
P1-25	Hyd	B/C	2.92	1,325	1.86	2.65
P1-25	Pred	B/C	3.05	1,388	1.94	2.78
P1-25	Est	B/C	3.22	1,474	2.05	2.95
P1-25	Har	B/C	3.22	1,474	2.05	2.95
P12-25	C	B/C	3.02	1,342	1.92	2.68
P12-25	Hyd	B/C	3.02	1,345	1.92	2.69
P12-25	Pred	B/C	3.16	1,410	2.01	2.82
P12-25	Est	B/C	3.34	1,496	2.12	2.99
P12-25	Har	B/C	3.34	1,496	2.12	2.99
P1-100	C	B/C	3.63	1,479	2.31	2.96
P1-100	Hyd	B/C	3.64	1,482	2.32	2.96
P1-100	Pred	B/C	3.80	1,552	2.42	3.10
P1-100	Est	B/C	4.01	1,647	2.56	3.29
P1-100	Har	B/C	4.01	1,647	2.56	3.29
P12-100	C	B/C	3.79	1,502	2.41	3.00
P12-100	Hyd	B/C	3.80	1,506	2.42	3.01
P12-100	Pred	B/C	3.96	1,577	2.52	3.15
P12-100	Est	B/C	4.19	1,672	2.67	3.34
P12-100	Har	B/C	4.19	1,672	2.67	3.34
P12-25	All	-25%	2.50	1,095	1.59	2.19
P12-100	All	-25%	3.14	1,230	2.00	2.46
P12-25	All	+25%	4.17	1,898	2.66	3.80
P12-100	All	+25%	5.24	2,114	3.34	4.23

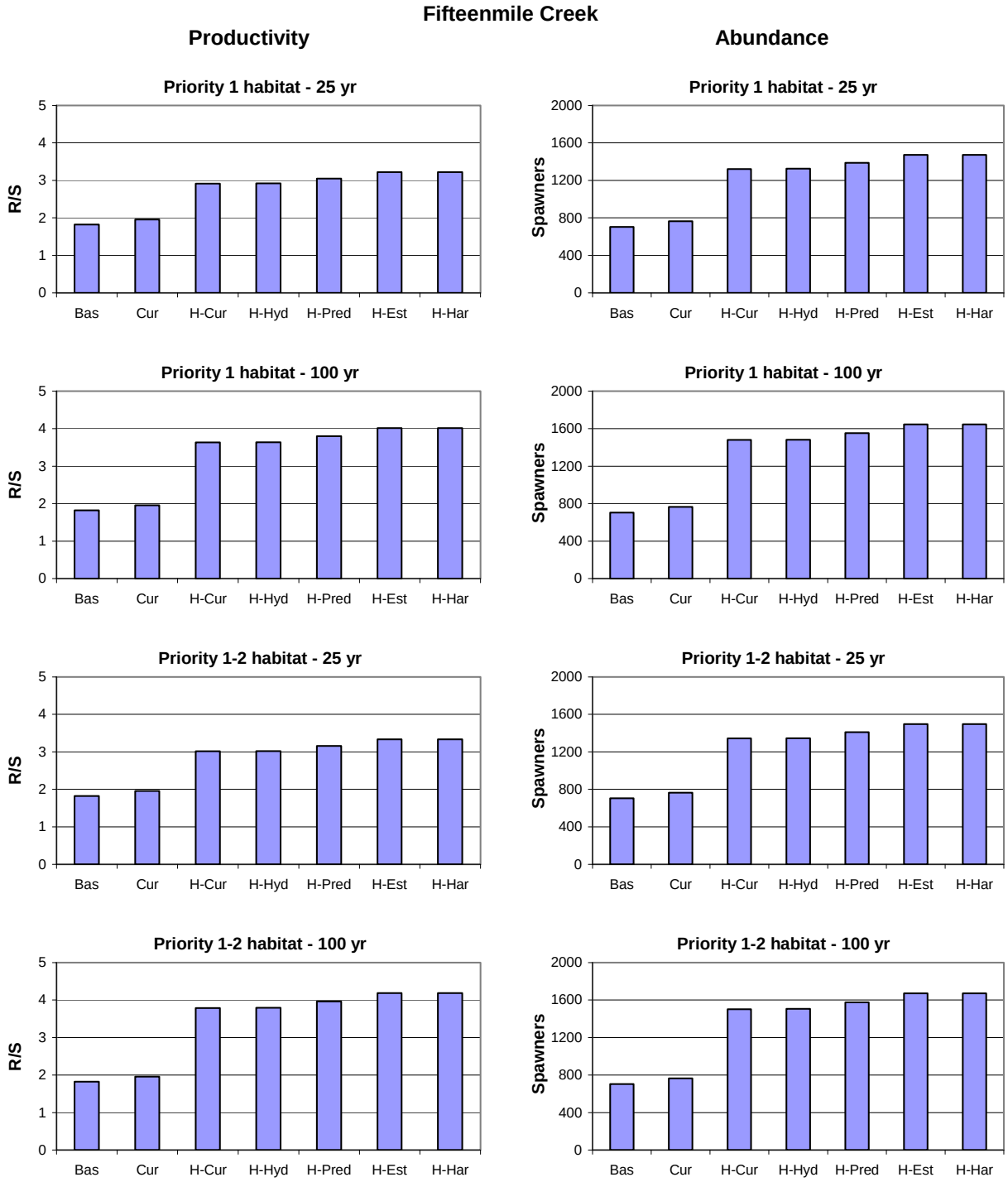


Figure 10-45. Estimated population performance (productivity and equilibrium abundance) of Fifteenmile Creek winter steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.2 Deschutes River Eastside Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of action measures. Very substantial benefits to both population productivity and natural-origin spawner abundance also occur as a result of reducing the number of stray hatchery fish that spawn with natural-origin fish.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. All scenario combinations result in threshold ratios >2 for both productivity and abundance, suggesting a very low risk of extinction over 100 years. Reductions in stray hatchery fish produce threshold ratios >4 and >7 for all scenario combinations for productivity and abundance, respectively.

Table 10-38 and figures 10-46 and 10-47 show estimated changes in population performance of Deschutes River Eastside population associated with tributary and out-of-subbasin actions.

Table 10-38. Estimated population performance (productivity and equilibrium abundance) of Deschutes River Eastside summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance				Threshold ratio			
			Prod		Abund		Prod		Abund	
Tributary	Main/est	Ocean	No stray action	Stray action	No stray action	Stray action	No stray action	Stray action	No stray action	Stray action
B	B	B/C	1.89		1,599		1.40		1.60	
B	C	B/C	2.10	3.71	2,340	4,634	1.55	2.75	2.34	4.63
P1-25	C	B/C	3.36	5.55	5,511	7,171	2.49	4.11	5.51	7.17
P1-25	Hyd	B/C	3.53	5.84	5,977	7,631	2.61	4.32	5.98	7.63
P1-25	Pred	B/C	3.69	6.10	6,398	8,047	2.73	4.52	6.40	8.05
P1-25	Est	B/C	3.89	6.45	6,958	8,600	2.88	4.78	6.96	8.60
P1-25	Har	B/C	3.89	6.45	6,958	8,600	2.88	4.78	6.96	8.60
P12-25	C	B/C	4.26	6.80	6,973	8,323	3.15	5.04	6.97	8.32
P12-25	Hyd	B/C	4.47	7.15	7,471	8,818	3.31	5.29	7.47	8.82
P12-25	Pred	B/C	4.67	7.47	7,921	9,265	3.46	5.53	7.92	9.27
P12-25	Est	B/C	4.93	7.89	8,520	9,859	3.65	5.85	8.52	9.86
P12-25	Har	B/C	4.93	7.89	8,520	9,859	3.65	5.85	8.52	9.86
P1-100	C	B/C	4.71	7.47	7,271	8,472	3.49	5.54	7.27	8.47
P1-100	Hyd	B/C	4.94	7.86	7,763	8,962	3.66	5.82	7.76	8.96
P1-100	Pred	B/C	5.16	8.21	8,208	9,405	3.82	6.08	8.21	9.41
P1-100	Est	B/C	5.44	8.68	8,799	9,994	4.03	6.43	8.80	9.99
P1-100	Har	B/C	5.44	8.68	8,799	9,994	4.03	6.43	8.80	9.99
P12-100	C	B/C	5.97	9.20	8,643	9,619	4.42	6.81	8.64	9.62
P12-100	Hyd	B/C	6.26	9.67	9,174	10,151	4.64	7.16	9.17	10.15
P12-100	Pred	B/C	6.53	10.10	9,656	10,632	4.84	7.48	9.66	10.63
P12-100	Est	B/C	6.89	10.68	10,295	11,272	5.10	7.91	10.30	11.27
P12-100	Har	B/C	6.89	10.68	10,295	11,272	5.10	7.91	10.30	11.27
P12-25	All	-25%	3.71	5.91	5,679	7,039	2.75	4.38	5.68	7.04
P12-100	All	-25%	5.22	8.00	7,265	8,239	3.87	5.93	7.26	8.24
P12-25	All	+25%	6.13	9.88	11,199	12,519	4.54	7.31	11.20	12.52
P12-100	All	+25%	8.54	13.35	13,167	14,140	6.33	9.89	13.17	14.14

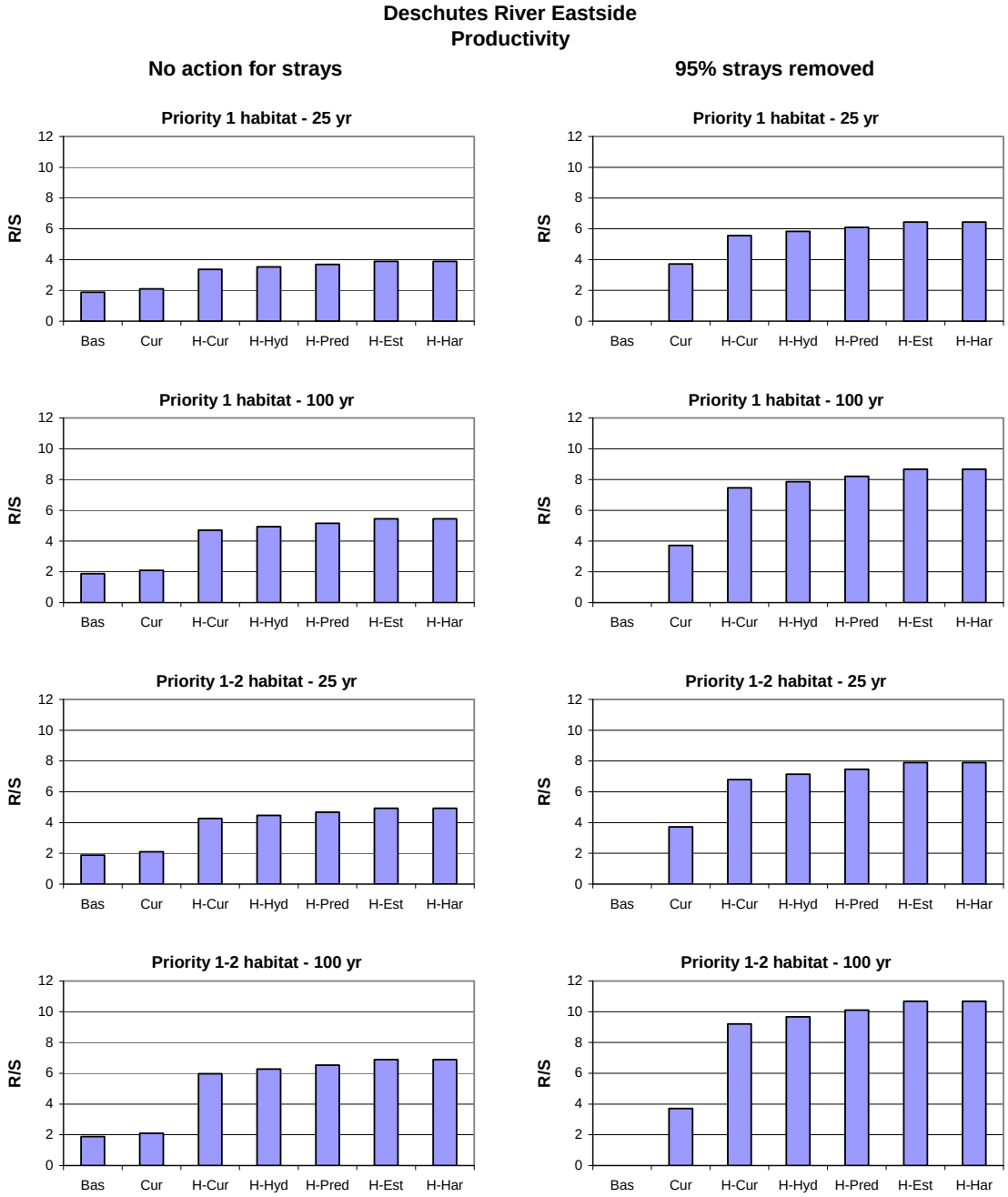


Figure 10-46. Estimated population productivity of Deschutes River Eastside summer steelhead associated with combinations of tributary and out-of-subbasin actions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

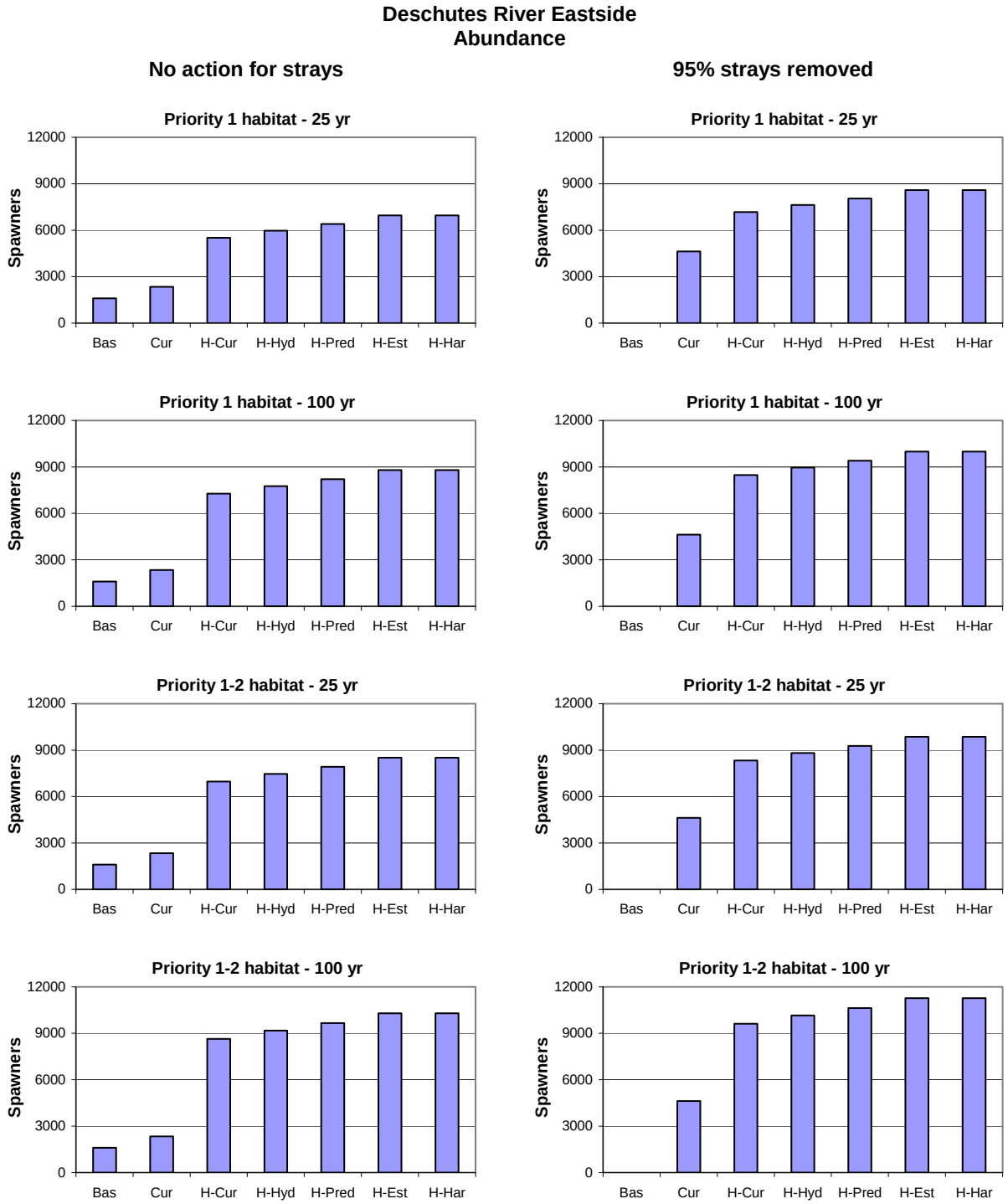


Figure 10-47. Estimated population equilibrium abundance of Deschutes River Eastside summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.3 Deschutes River Westside Summer Steelhead, Projected Changes to Population Performance

The largest increases in population performance associated with the range of scenario combinations analyzed occur as a result of decreasing the number of stray hatchery fish and/or by providing passage at the Pelton-Round Butte complex (includes passage at Whychus Creek barriers). In the absence of the removal of strays or passage, benefits are much reduced. For those scenario combinations lacking removal of strays and passage, beneficial effects of tributary actions are greatest, though beneficial cumulative effects of adding in mainstem actions are clearly evident. The more modest benefits associated with tributary actions than found for the Deschutes Eastside population are due to the much better condition of tributary habitat in general compared to that on the east side of the subbasin (as reflected in how habitat conditions were characterized in EDT). We also hypothesize that performance of anadromous *O. mykiss* in west side tributaries is constrained in part by the significant presence of the resident form of *O. mykiss* in these streams.

The viability threshold for productivity is exceeded for all action scenarios, including ones associated with a 25% decrease in marine survival (threshold ratio >1 in all cases). It is noted however that the productivity threshold is tied to the minimum abundance threshold, which for this population, is not exceeded for any scenario combination considered. This suggests that the population would remain at significant risk of extinction despite the full range of actions considered. Only with all actions implemented and a 25% improvement in marine survival is the abundance threshold ratio of 1 approached (but still remaining <1). We hypothesize that this is, at least in part, due to a constraining influence of the presence of resident *O. mykiss* on abundance.

Table 10-39 and figures 10-48, 10-49 and 10-50 show changes in population performance of the Deschutes River Westside population associated with tributary and out-of-subbasin actions.

Table 10-39. Estimated population performance (productivity and equilibrium abundance) of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without passage at Pelton-Round Butte Complex and with and without action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance					
			Prod			Abund		
Tributary	Main/est	Ocean	No passage - no stray action	No passage - with stray action	Passage - with stray action	No passage - no stray action	No passage - with stray action	Passage - with stray action
B	B	B/C	1.05			456		
B	C	B/C	1.17	1.84		514	557	
P1-25	C	B/C	1.44	2.23	2.18	550	585	838
P1-25	Hyd	B/C	1.51	2.35	2.29	581	615	882
P1-25	Pred	B/C	1.57	2.45	2.39	608	643	921
P1-25	Est	B/C	1.66	2.59	2.52	645	679	973
P1-25	Har	B/C	1.66	2.59	2.52	645	679	973
P12-25	C	B/C	1.59	2.44	2.39	578	610	880
P12-25	Hyd	B/C	1.67	2.57	2.52	610	641	925
P12-25	Pred	B/C	1.74	2.68	2.63	638	669	966
P12-25	Est	B/C	1.84	2.84	2.78	675	707	1,020
P12-25	Har	B/C	1.84	2.84	2.78	675	707	1,020
P1-100	C	B/C	1.63	2.50	2.42	587	618	887
P1-100	Hyd	B/C	1.71	2.63	2.54	618	649	932
P1-100	Pred	B/C	1.78	2.74	2.66	647	678	974
P1-100	Est	B/C	1.88	2.90	2.81	684	715	1,028
P1-100	Har	B/C	1.88	2.90	2.81	684	715	1,028
P12-100	C	B/C	1.82	2.78	2.74	630	660	931
P12-100	Hyd	B/C	1.92	2.92	2.88	665	694	978
P12-100	Pred	B/C	2.00	3.05	3.01	696	725	1,020
P12-100	Est	B/C	2.11	3.23	3.18	738	767	1,077
P12-100	Har	B/C	2.11	3.23	3.18	738	767	1,077
P12-25	All	-25%	1.38	2.13	2.08	497	530	763
P12-100	All	-25%	1.59	2.42	2.39	542	571	810
P12-25	All	+25%	2.29	3.55	3.47	844	875	1,263
P12-100	All	+25%	2.64	4.03	3.98	927	955	1,329

Table 10-39. Continued.

Scenario combination			Threshold ratio					
			Prod			Abund		
Tributary	Main/est	Ocean	No passage - no stray action	No passage - with stray action	Passage - with stray action	No passage - no stray action	No passage - with stray action	Passage - with stray action
B	B	B/C	0.78			0.46		
B	C	B/C	0.86	1.36		0.51	0.56	
P1-25	C	B/C	1.06	1.66	1.73	0.55	0.59	0.56
P1-25	Hyd	B/C	1.12	1.74	1.81	0.58	0.62	0.59
P1-25	Pred	B/C	1.17	1.82	1.89	0.61	0.64	0.61
P1-25	Est	B/C	1.23	1.92	2.00	0.64	0.68	0.65
P1-25	Har	B/C	1.23	1.92	2.00	0.64	0.68	0.65
P12-25	C	B/C	1.18	1.81	1.90	0.58	0.61	0.59
P12-25	Hyd	B/C	1.24	1.90	2.00	0.61	0.64	0.62
P12-25	Pred	B/C	1.29	1.99	2.09	0.64	0.67	0.64
P12-25	Est	B/C	1.36	2.10	2.20	0.68	0.71	0.68
P12-25	Har	B/C	1.36	2.10	2.20	0.68	0.71	0.68
P1-100	C	B/C	1.21	1.85	1.92	0.59	0.62	0.59
P1-100	Hyd	B/C	1.27	1.94	2.02	0.62	0.65	0.62
P1-100	Pred	B/C	1.32	2.03	2.11	0.65	0.68	0.65
P1-100	Est	B/C	1.40	2.15	2.23	0.68	0.72	0.69
P1-100	Har	B/C	1.40	2.15	2.23	0.68	0.72	0.69
P12-100	C	B/C	1.35	2.06	2.18	0.63	0.66	0.62
P12-100	Hyd	B/C	1.42	2.16	2.29	0.66	0.69	0.65
P12-100	Pred	B/C	1.48	2.26	2.39	0.70	0.73	0.68
P12-100	Est	B/C	1.57	2.39	2.53	0.74	0.77	0.72
P12-100	Har	B/C	1.57	2.39	2.53	0.74	0.77	0.72
P12-25	All	-25%	1.02	1.58	1.65	0.50	0.53	0.51
P12-100	All	-25%	1.18	1.79	1.89	0.54	0.57	0.54
P12-25	All	+25%	1.70	2.63	2.76	0.84	0.88	0.84
P12-100	All	+25%	1.95	2.99	3.16	0.93	0.96	0.89

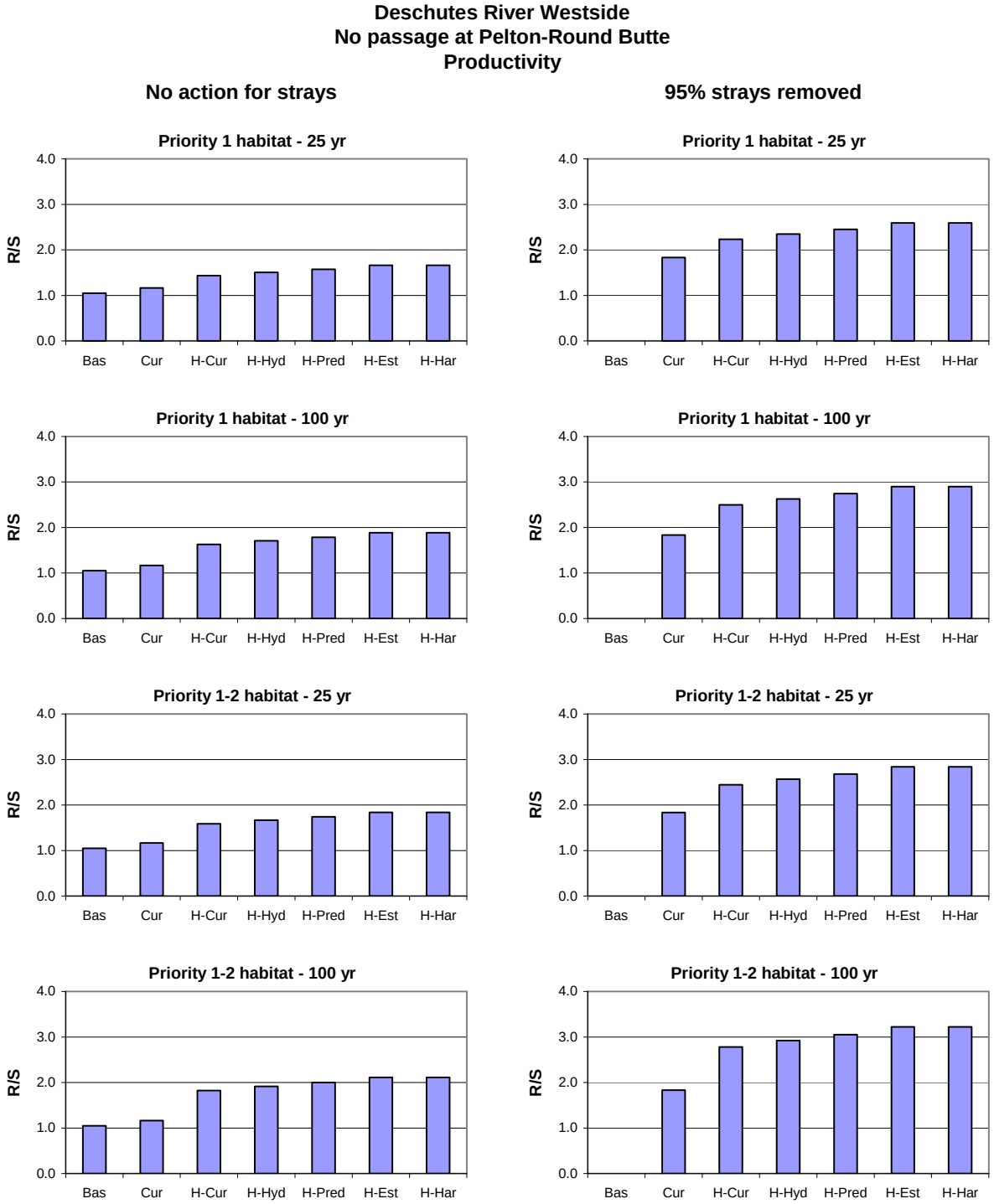


Figure 10-48. Estimated population productivity of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions and no passage at Pelton-Round Butte Complex. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

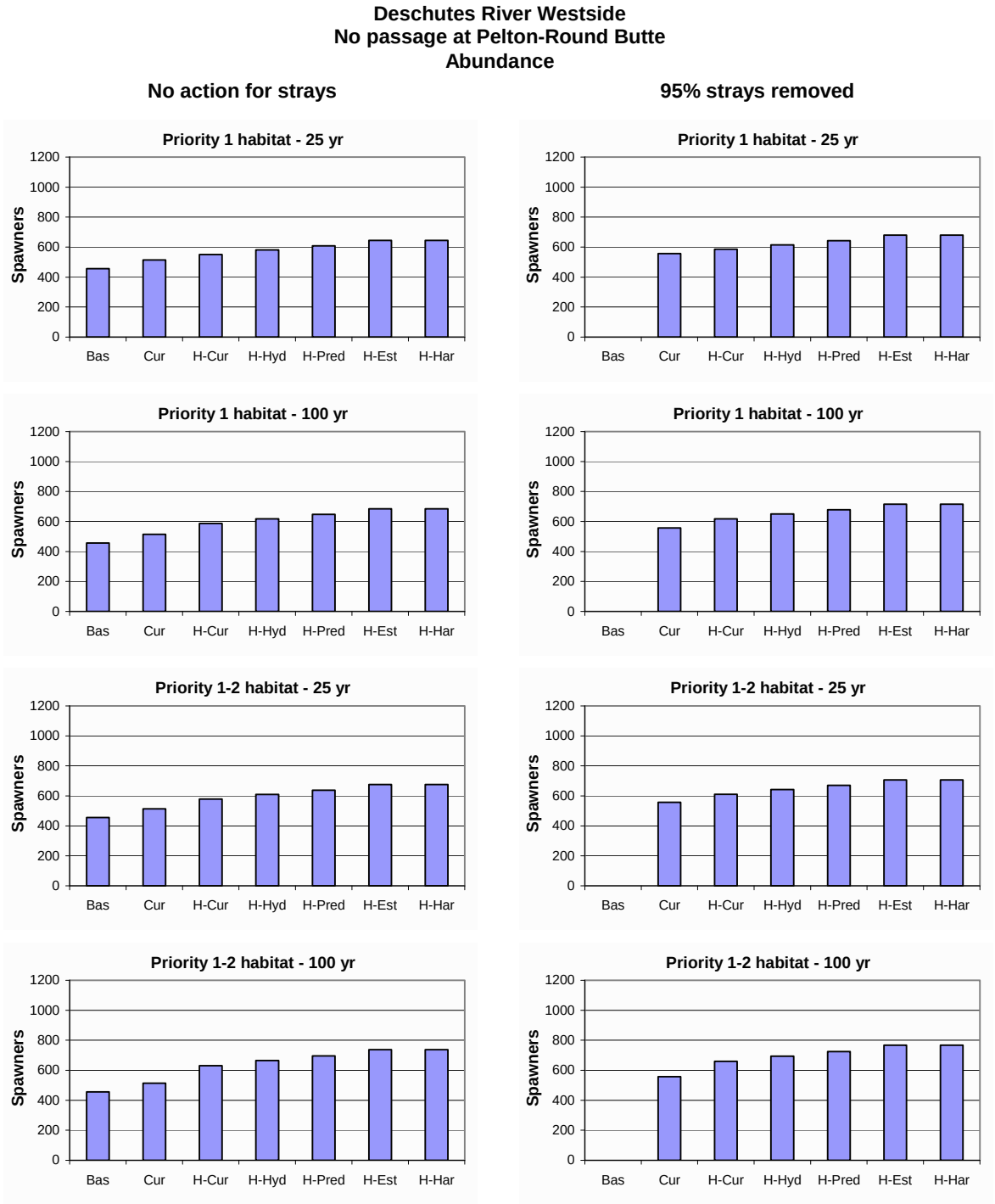


Figure 10-49. Estimated population equilibrium abundance of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions and no passage at Pelton-Round Butte Complex. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with and without action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

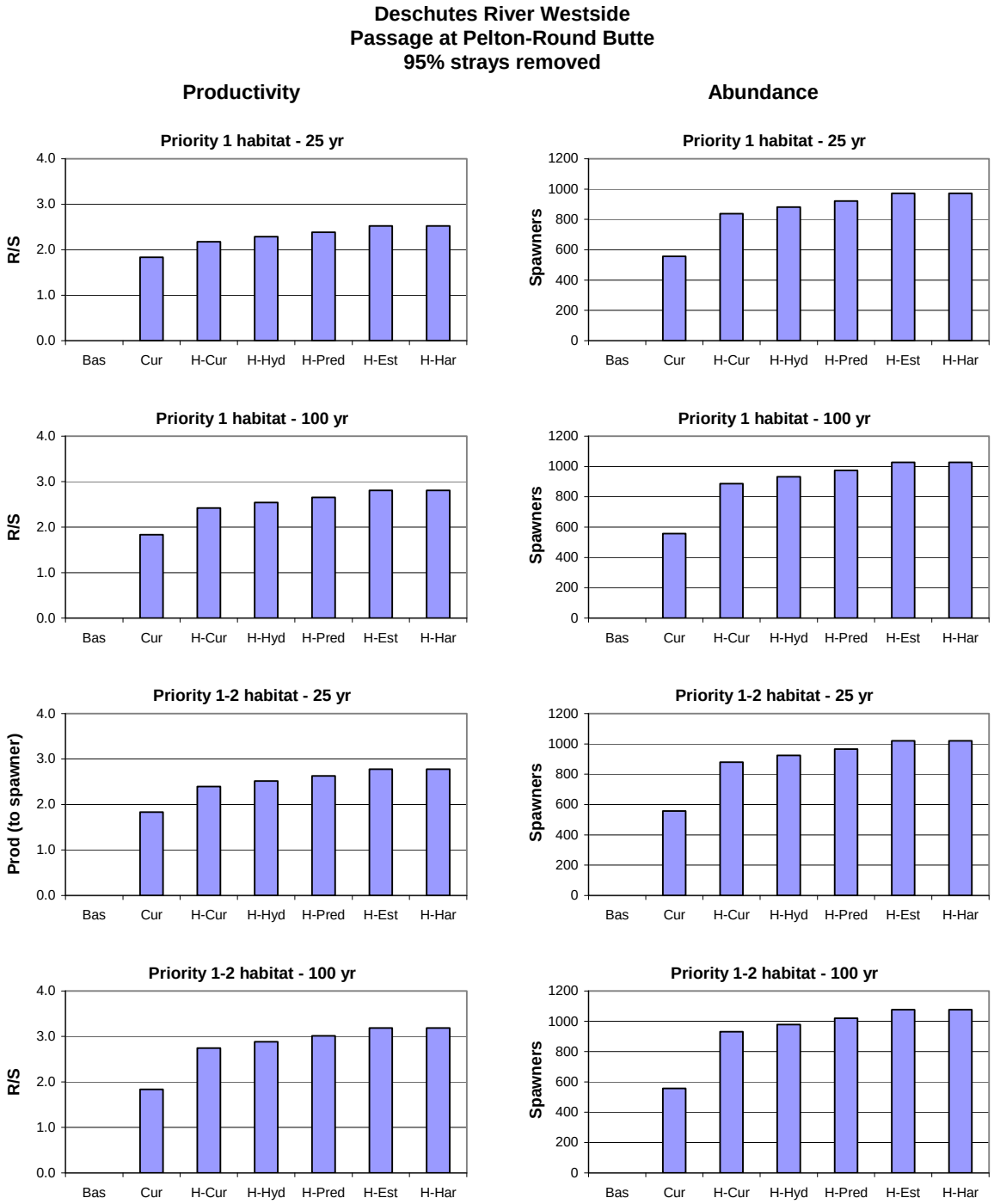


Figure 10-50. Estimated population performance measures (productivity and equilibrium abundance) of Deschutes River Westside summer steelhead associated with combinations of tributary and out-of-subbasin actions and with passage at Pelton-Round Butte Complex. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Results are shown with action to reduce the number of hatchery strays by 95% of those expected to enter the relevant area for the scenario. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.4 Lower Mainstem John Day River Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. All scenario combinations result in threshold ratios >4 (approximately) for productivity and >2 for abundance, suggesting a very low risk of extinction over 100 years.

Table 10-40 and Figure 10-51 show projected changes in estimated population performance of Lower Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions.

Table 10-40. Estimated population performance (productivity and equilibrium abundance) of Lower Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	2.99	1,800	2.51	0.80
B	C	B/C	3.44	2,423	2.89	1.08
P1-25	C	B/C	4.75	4,743	3.99	2.11
P1-25	Hyd	B/C	5.18	5,393	4.35	2.40
P1-25	Pred	B/C	5.39	5,706	4.53	2.54
P1-25	Est	B/C	5.67	6,122	4.77	2.72
P1-25	Har	B/C	5.67	6,122	4.77	2.72
P12-25	C	B/C	4.99	5,751	4.19	2.56
P12-25	Hyd	B/C	5.43	6,537	4.56	2.91
P12-25	Pred	B/C	5.65	6,918	4.74	3.07
P12-25	Est	B/C	5.94	7,427	4.99	3.30
P12-25	Har	B/C	5.94	7,427	4.99	3.30
P1-100	C	B/C	6.20	6,547	5.21	2.91
P1-100	Hyd	B/C	6.74	7,324	5.67	3.26
P1-100	Pred	B/C	7.01	7,699	5.89	3.42
P1-100	Est	B/C	7.37	8,197	6.19	3.64
P1-100	Har	B/C	7.37	8,197	6.19	3.64
P12-100	C	B/C	7.31	8,627	6.15	3.83
P12-100	Hyd	B/C	7.94	9,628	6.67	4.28
P12-100	Pred	B/C	8.25	10,112	6.93	4.49
P12-100	Est	B/C	8.67	10,758	7.29	4.78
P12-100	Har	B/C	8.67	10,758	7.29	4.78
P12-25	All	-25%	4.61	5,047	3.87	2.24
P12-100	All	-25%	6.77	7,728	5.69	3.43
P12-25	All	+25%	7.33	9,722	6.16	4.32
P12-100	All	+25%	10.66	13,667	8.96	6.07

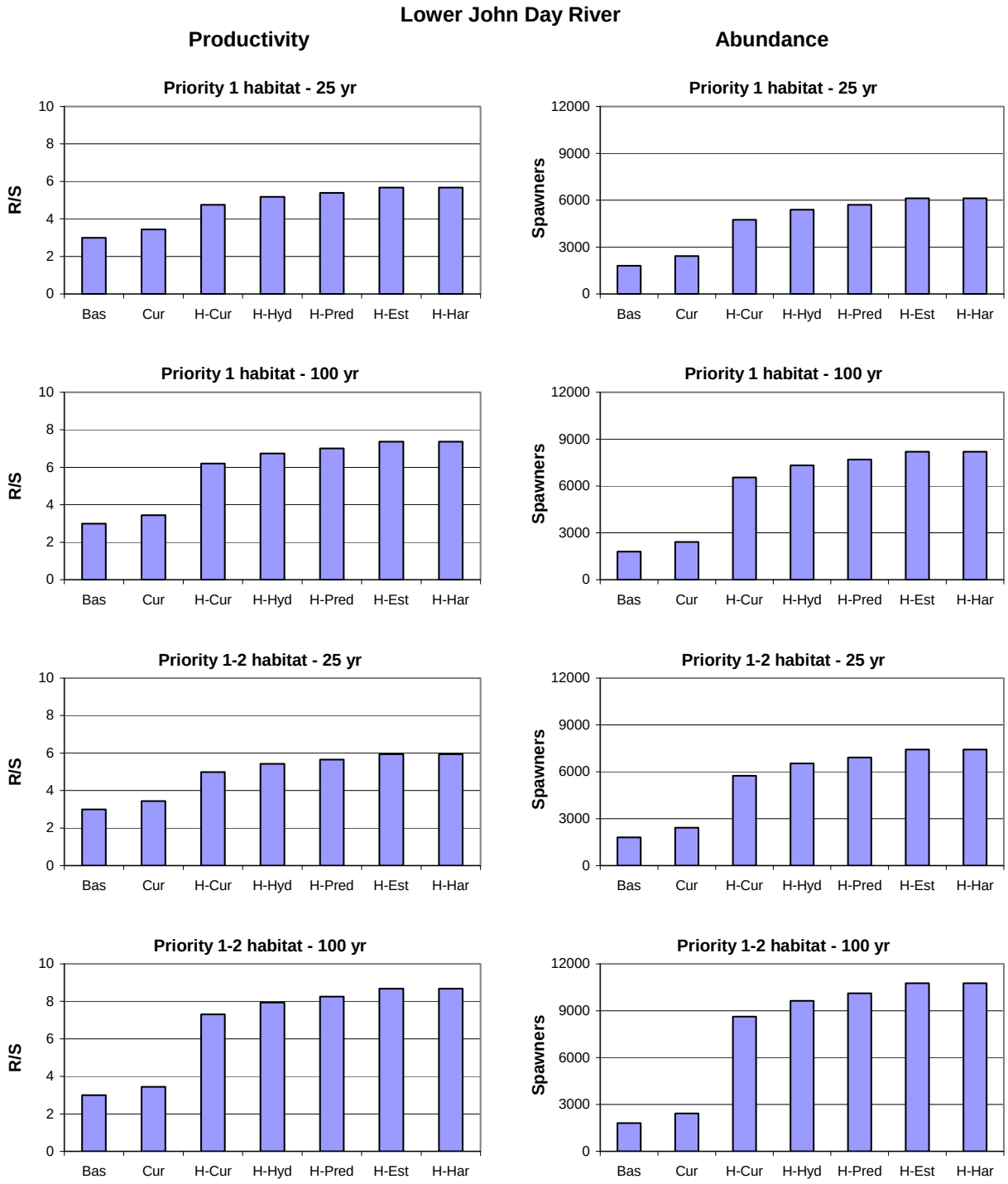


Figure 10-51. Estimated population performance measures (productivity and equilibrium abundance) of Lower Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.5 North Fork John Day River Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. Most scenario combinations result in threshold ratios >3 for productivity and >2 for abundance, suggesting a very low risk of extinction over 100 years.

Table 10-41 and Figure 10-52 show projected changes in population performance of North Fork John Day River summer steelhead associated with tributary and out-of-subbasin actions.

Table 10-41. Estimated population performance (productivity and equilibrium abundance) of North Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	2.41	1,740	1.91	1.16
B	C	B/C	2.77	2,101	2.20	1.40
P1-25	C	B/C	3.34	2,678	2.65	1.79
P1-25	Hyd	B/C	3.66	2,999	2.91	2.00
P1-25	Pred	B/C	3.82	3,153	3.03	2.10
P1-25	Est	B/C	4.04	3,358	3.20	2.24
P1-25	Har	B/C	4.04	3,358	3.20	2.24
P12-25	C	B/C	3.44	2,762	2.73	1.84
P12-25	Hyd	B/C	3.77	3,090	3.00	2.06
P12-25	Pred	B/C	3.94	3,248	3.13	2.17
P12-25	Est	B/C	4.16	3,458	3.30	2.31
P12-25	Har	B/C	4.16	3,458	3.30	2.31
P1-100	C	B/C	3.84	3,078	3.04	2.05
P1-100	Hyd	B/C	4.21	3,432	3.34	2.29
P1-100	Pred	B/C	4.39	3,603	3.48	2.40
P1-100	Est	B/C	4.63	3,830	3.68	2.55
P1-100	Har	B/C	4.63	3,830	3.68	2.55
P12-100	C	B/C	4.03	3,209	3.20	2.14
P12-100	Hyd	B/C	4.42	3,572	3.51	2.38
P12-100	Pred	B/C	4.61	3,747	3.66	2.50
P12-100	Est	B/C	4.87	3,980	3.86	2.65
P12-100	Har	B/C	4.87	3,980	3.86	2.65
P12-25	All	-25%	3.14	2,465	2.49	1.64
P12-100	All	-25%	3.69	2,880	2.93	1.92
P12-25	All	+25%	5.18	4,404	4.11	2.94
P12-100	All	+25%	6.06	5,028	4.81	3.35

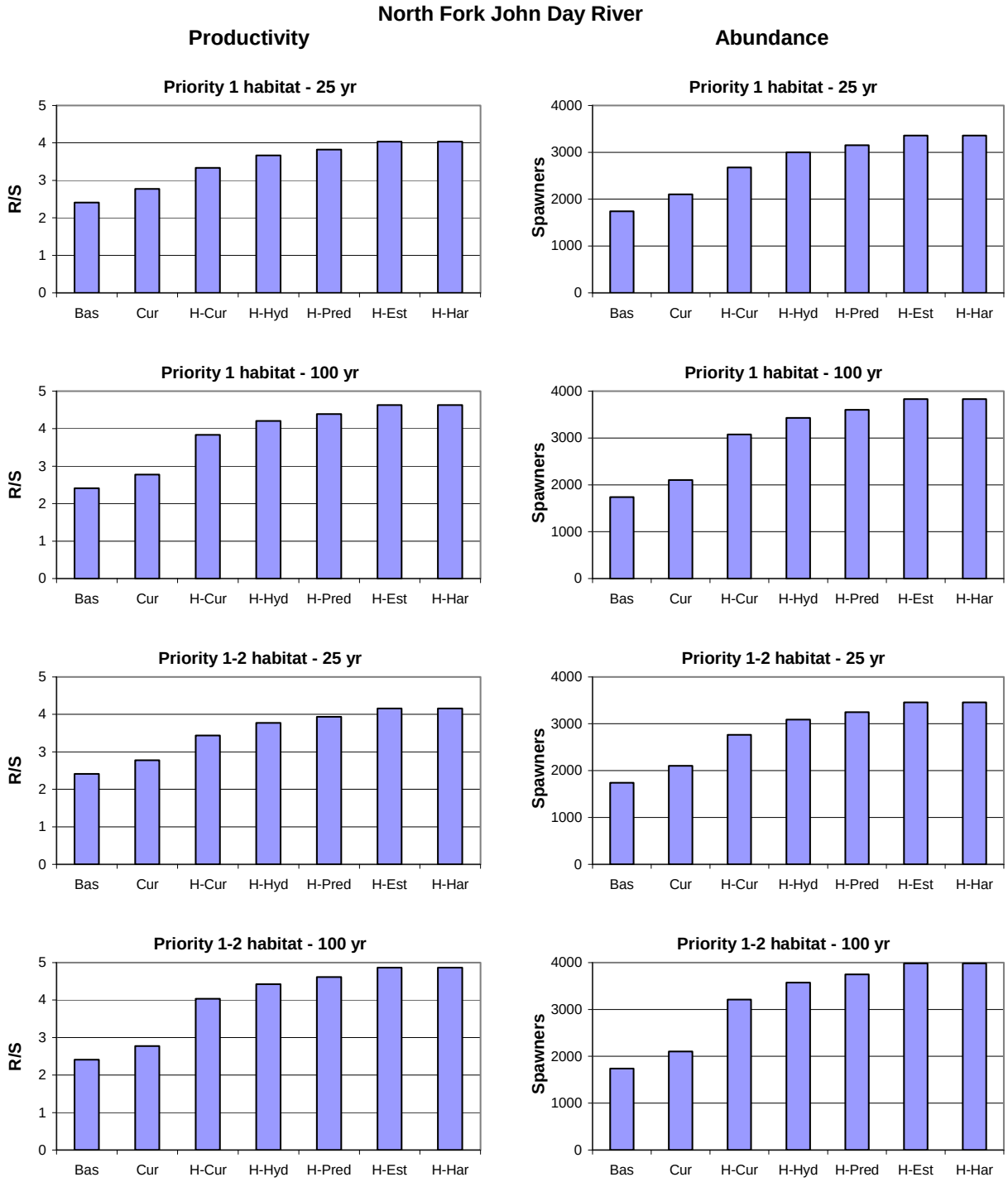


Figure 10-52. Estimated population performance measures (productivity and equilibrium abundance) of North Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.6 Middle Fork John Day River Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100-year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. Most scenario combinations result in threshold ratios >3 for productivity. Threshold ratios for abundance across the range of scenario combinations are lower, generally between values of 1-2.

Table 10-42 and Figure 10-53 show projected changes to population performance of Middle Fork John Day River summer steelhead associated with tributary and out-of-subbasin actions.

Table 10-42. Estimated population performance (productivity and equilibrium abundance) of Middle Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	2.45	756	1.81	0.76
B	C	B/C	2.82	921	2.09	0.92
P1-25	C	B/C	4.01	1,313	2.97	1.31
P1-25	Hyd	B/C	4.40	1,467	3.26	1.47
P1-25	Pred	B/C	4.59	1,541	3.40	1.54
P1-25	Est	B/C	4.84	1,640	3.59	1.64
P1-25	Har	B/C	4.84	1,640	3.59	1.64
P12-25	C	B/C	4.24	1,385	3.14	1.38
P12-25	Hyd	B/C	4.64	1,545	3.44	1.54
P12-25	Pred	B/C	4.84	1,622	3.59	1.62
P12-25	Est	B/C	5.11	1,724	3.79	1.72
P12-25	Har	B/C	5.11	1,724	3.79	1.72
P1-100	C	B/C	5.09	1,579	3.77	1.58
P1-100	Hyd	B/C	5.57	1,753	4.13	1.75
P1-100	Pred	B/C	5.81	1,837	4.30	1.84
P1-100	Est	B/C	6.13	1,948	4.54	1.95
P1-100	Har	B/C	6.13	1,948	4.54	1.95
P12-100	C	B/C	5.46	1,694	4.04	1.69
P12-100	Hyd	B/C	5.97	1,878	4.43	1.88
P12-100	Pred	B/C	6.23	1,966	4.61	1.97
P12-100	Est	B/C	6.57	2,084	4.86	2.08
P12-100	Har	B/C	6.57	2,084	4.86	2.08
P12-25	All	-25%	3.88	1,240	2.87	1.24
P12-100	All	-25%	5.00	1,528	3.70	1.53
P12-25	All	+25%	6.35	2,186	4.70	2.19
P12-100	All	+25%	8.15	2,616	6.03	2.62

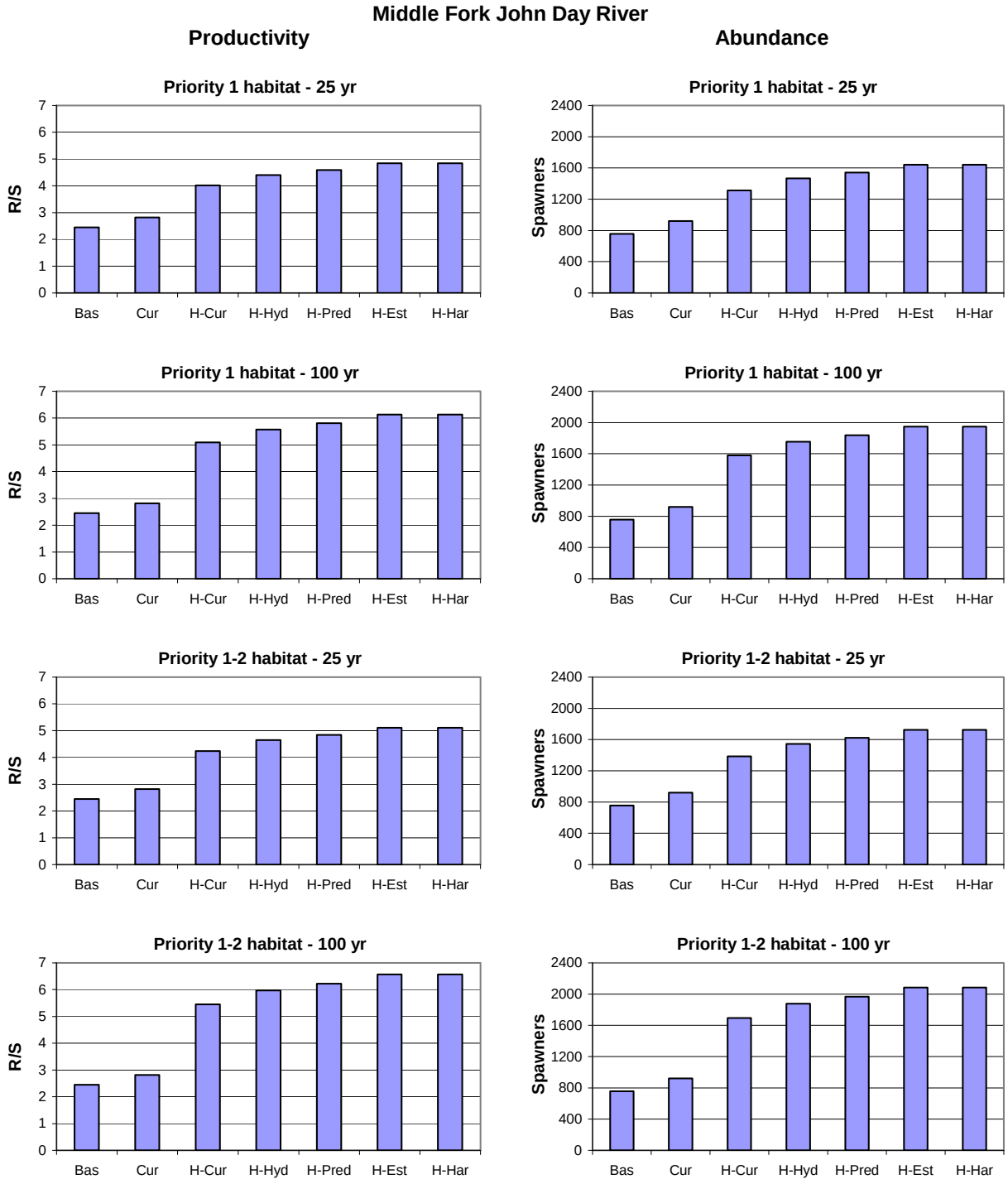


Figure 10-53. Estimated population performance measures (productivity and equilibrium abundance) of Middle Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.7 South Fork John Day River Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100 year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

The viability threshold for productivity is exceeded for all action scenarios, including ones associated with a 25% decrease in marine survival (threshold ratio >1 in all cases). It is noted however that the productivity threshold is tied to the minimum abundance threshold, which for this population, is not exceeded for approximately half of the scenario combinations considered. Only at 100 years, after some tributary habitat actions have fully matured, in combination with addition of mainstem actions, does the threshold ratio for abundance >1. The abundance ratio with all actions implemented, even after 100 years of maturation, drops to <1 when marine survival is reduced to 75% of the current average.

Table 10-43 and Figure 10-54 show projected changes in population performance of South Fork John Day River summer steelhead associated with tributary and out-of-subbasin actions.

Table 10-43. Estimated population performance (productivity and equilibrium abundance) of South Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for ICTRT baseline conditions. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	2.06	259	1.31	0.52
B	C	B/C	2.37	315	1.51	0.63
P1-25	C	B/C	2.86	391	1.82	0.78
P1-25	Hyd	B/C	3.14	439	2.00	0.88
P1-25	Pred	B/C	3.28	462	2.09	0.92
P1-25	Est	B/C	3.46	492	2.21	0.98
P1-25	Har	B/C	3.46	492	2.21	0.98
P12-25	C	B/C	3.03	414	1.93	0.83
P12-25	Hyd	B/C	3.32	464	2.11	0.93
P12-25	Pred	B/C	3.46	488	2.21	0.98
P12-25	Est	B/C	3.66	520	2.33	1.04
P12-25	Har	B/C	3.66	520	2.33	1.04
P1-100	C	B/C	3.35	454	2.14	0.91
P1-100	Hyd	B/C	3.68	506	2.34	1.01
P1-100	Pred	B/C	3.84	532	2.44	1.06
P1-100	Est	B/C	4.05	566	2.58	1.13
P1-100	Har	B/C	4.05	566	2.58	1.13
P12-100	C	B/C	3.72	491	2.37	0.98
P12-100	Hyd	B/C	4.07	546	2.59	1.09
P12-100	Pred	B/C	4.25	573	2.70	1.15
P12-100	Est	B/C	4.48	609	2.85	1.22
P12-100	Har	B/C	4.48	609	2.85	1.22
P12-25	All	-25%	2.76	369	1.76	0.74
P12-100	All	-25%	3.40	440	2.16	0.88
P12-25	All	+25%	4.55	665	2.90	1.33
P12-100	All	+25%	5.57	769	3.55	1.54

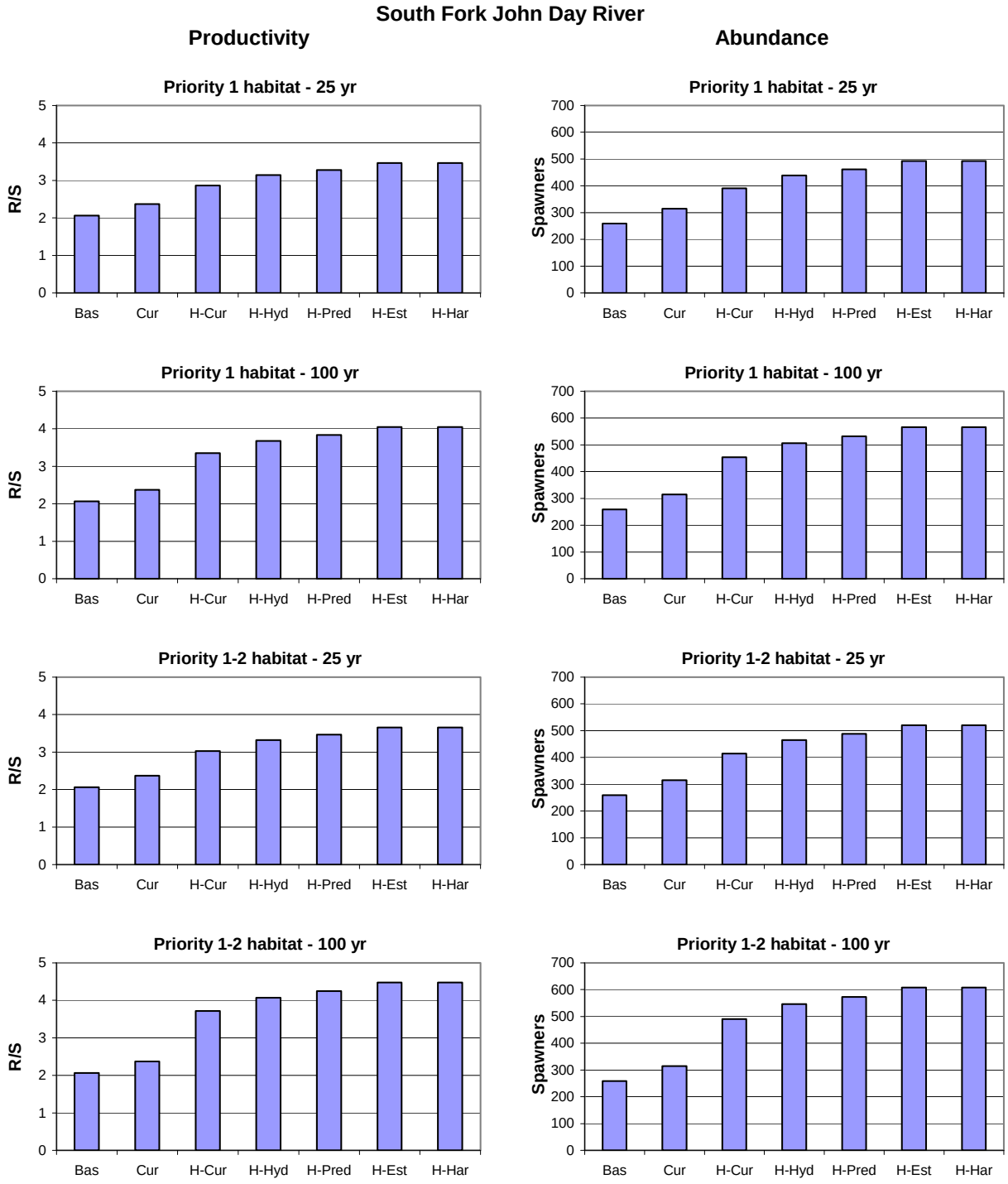


Figure 10-54. Estimated population performance measures (productivity and equilibrium abundance) of South Fork John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.8 Upper Mainstem John Day River Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100 year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. All scenario combinations result in threshold ratios between 2 and 5 for productivity. Most scenario combinations result in abundance threshold ratios between 1 and 2. These abundance threshold ratios are, however, markedly higher than the current ratio value.

Table 10-44 and Figure 10-55 show projected changes in population performance of Upper Mainstem John Day River summer steelhead associated with tributary and out-of-subbasin actions.

Table 10-44. Estimated population performance (productivity and equilibrium abundance) of Upper Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	2.14	524	1.59	0.52
B	C	B/C	2.46	650	1.82	0.65
P1-25	C	B/C	3.24	955	2.40	0.96
P1-25	Hyd	B/C	3.55	1,076	2.63	1.08
P1-25	Pred	B/C	3.70	1,134	2.74	1.13
P1-25	Est	B/C	3.91	1,212	2.89	1.21
P1-25	Har	B/C	3.91	1,212	2.89	1.21
P12-25	C	B/C	4.14	1,262	3.06	1.26
P12-25	Hyd	B/C	4.52	1,409	3.35	1.41
P12-25	Pred	B/C	4.71	1,480	3.49	1.48
P12-25	Est	B/C	4.97	1,575	3.68	1.58
P12-25	Har	B/C	4.97	1,575	3.68	1.58
P1-100	C	B/C	3.95	1,160	2.92	1.16
P1-100	Hyd	B/C	4.32	1,298	3.20	1.30
P1-100	Pred	B/C	4.50	1,364	3.33	1.36
P1-100	Est	B/C	4.75	1,452	3.51	1.45
P1-100	Har	B/C	4.75	1,452	3.51	1.45
P12-100	C	B/C	5.35	1,566	3.97	1.57
P12-100	Hyd	B/C	5.85	1,738	4.33	1.74
P12-100	Pred	B/C	6.09	1,821	4.51	1.82
P12-100	Est	B/C	6.42	1,931	4.76	1.93
P12-100	Har	B/C	6.42	1,931	4.76	1.93
P12-25	All	-25%	3.79	1,129	2.81	1.13
P12-100	All	-25%	4.91	1,411	3.64	1.41
P12-25	All	+25%	6.16	2,004	4.56	2.00
P12-100	All	+25%	7.95	2,431	5.89	2.43

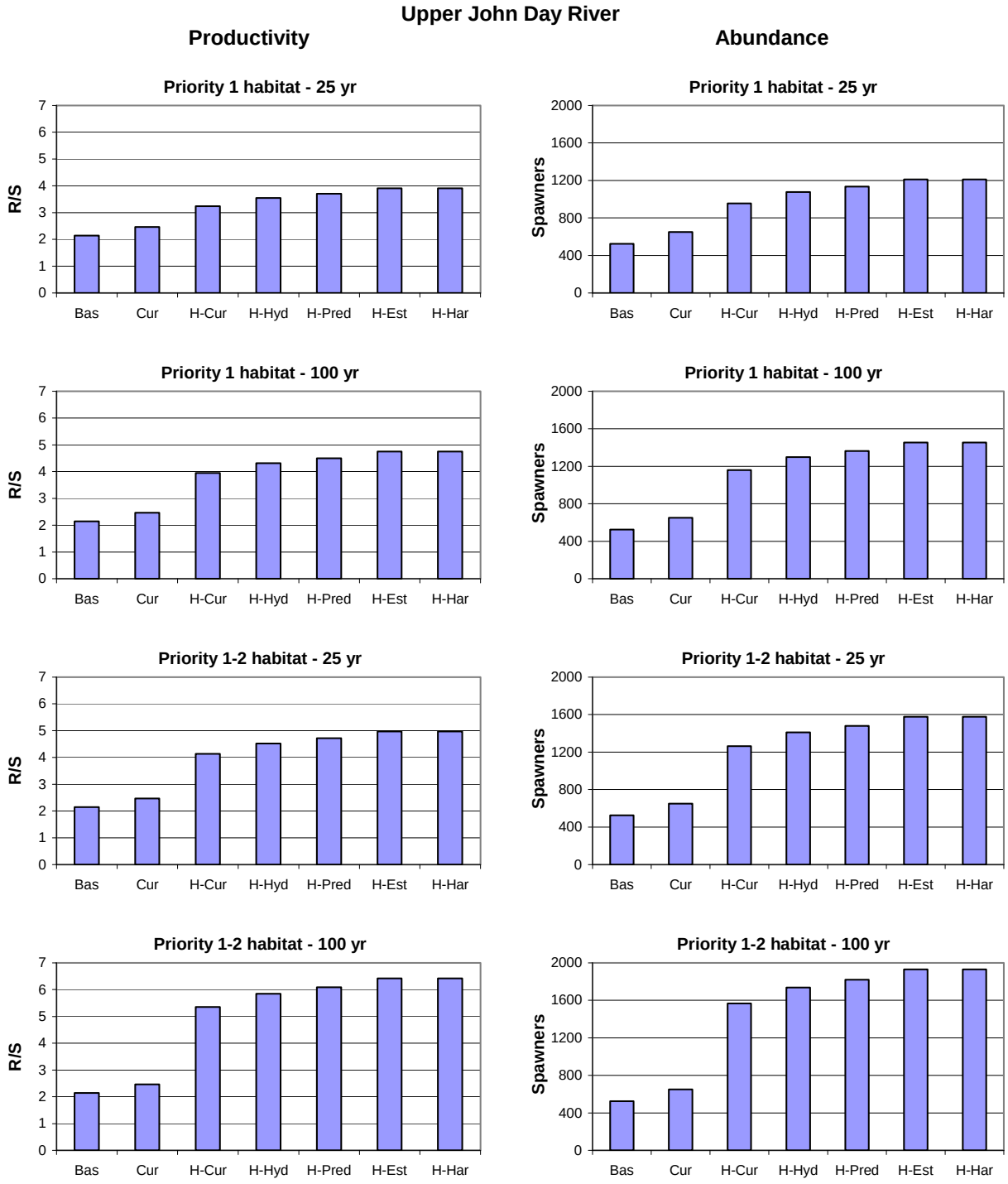


Figure 10-55. Estimated population performance measures (productivity and equilibrium abundance) of Upper Mainstem John Day River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.9 Umatilla River Summer Steelhead, Projected Changes to Population Performance

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations analyzed. The largest contribution to performance improvements is estimated to be due to tributary habitat actions, with greatest benefits accruing for the 100 year scenarios. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. All scenario combinations result in threshold ratios between 2-5 for both productivity and abundance, suggesting a very low risk of extinction over 100 years.

Table 10-45 and Figure 10-56 show projected changes in population performance of Umatilla River summer steelhead associated with combinations of tributary and out-of-subbasin actions.

Table 10-45. Estimated population performance (productivity and equilibrium abundance) of Umatilla River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	1.50	1,472	1.19	0.98
B	C	B/C	1.73	1,820	1.37	1.21
P1-25	C	B/C	3.30	3,373	2.62	2.25
P1-25	Hyd	B/C	3.63	3,748	2.88	2.50
P1-25	Pred	B/C	3.79	3,929	3.01	2.62
P1-25	Est	B/C	4.01	4,168	3.18	2.78
P1-25	Har	B/C	4.01	4,168	3.18	2.78
P12-25	C	B/C	3.18	3,685	2.52	2.46
P12-25	Hyd	B/C	3.50	4,092	2.77	2.73
P12-25	Pred	B/C	3.65	4,287	2.90	2.86
P12-25	Est	B/C	3.86	4,545	3.06	3.03
P12-25	Har	B/C	3.86	4,545	3.06	3.03
P1-100	C	B/C	4.26	3,954	3.38	2.64
P1-100	Hyd	B/C	4.68	4,366	3.71	2.91
P1-100	Pred	B/C	4.89	4,564	3.88	3.04
P1-100	Est	B/C	5.16	4,827	4.10	3.22
P1-100	Har	B/C	5.16	4,827	4.10	3.22
P12-100	C	B/C	4.03	4,355	3.20	2.90
P12-100	Hyd	B/C	4.42	4,808	3.51	3.21
P12-100	Pred	B/C	4.62	5,026	3.66	3.35
P12-100	Est	B/C	4.88	5,314	3.87	3.54
P12-100	Har	B/C	4.88	5,314	3.87	3.54
P12-25	All	-25%	2.90	3,313	2.30	2.21
P12-100	All	-25%	3.67	3,940	2.91	2.63
P12-25	All	+25%	4.82	5,693	3.83	3.80
P12-100	All	+25%	6.09	6,592	4.83	4.39

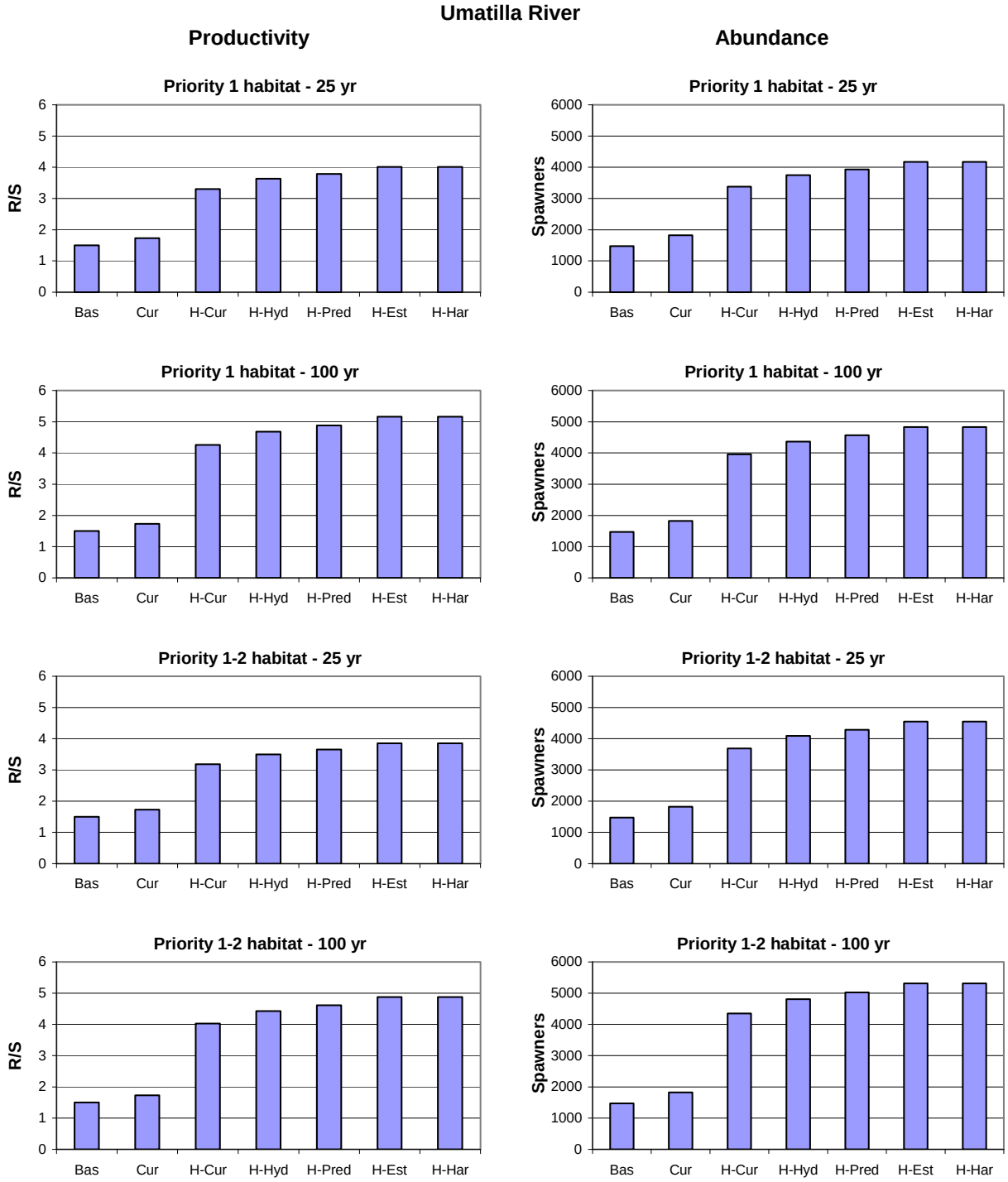


Figure 10-56. Estimated population performance measures (productivity and equilibrium abundance) of Umatilla River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.3.10 Walla Walla River Summer Steelhead, Projected Changes to Population Performance

We ran two sets of model runs for the Walla Walla River population. The first set included tributary habitat actions described in this plan, most of which were within the geographic boundaries of the state of Oregon. The second set of model runs included the tributary habitat actions identified in this plan, and in addition included the tributary habitat action scenarios modeled in the subbasin planning process within the boundaries of the state of Washington. For both sets of model runs, we used the out-of-subbasin survival improvements previously described in this section.

Action Effectiveness for Action Analysis Used in the Subbasin Plan
The approach used to model action effectiveness within the Washington Walla Walla subbasin planning process (carried forward into the Washington Walla Walla steelhead recovery plan) was less rigorous and less specific to actual proposed actions than the Oregon planning process.

Formulation of action strategies and effectiveness modeling in the subbasin planning process was done in three steps or components: working hypotheses, biological objectives, and strategies. Working hypotheses were the conclusions derived through the EDT diagnostic analysis about limiting factors. The second step was to establish restoration objectives for each of the limiting factors targeted for the analysis. These objectives were set for individual areas of the subbasin based on what the subbasin planning team assumed about what might be realistically attainable. For example, the percentage of pool habitat within a section of the mainstem river had been characterized to be 10% of the wetted surface area. The historical condition was hypothesized to be 20% of the wetted surface area. The biological objective for restoration in this case was set to be 20%. In other reaches, or for other habitat attributes, the objective was set to be intermediate between current condition and historical condition as it was hypothesized to exist. These biological objectives then prescribed a level of action effectiveness needed to achieve each objective, where the action represented whatever kinds of strategies might be employed to achieve the attribute specific objectives. Therefore, action effectiveness was not actually defined by the team, but became a by-product of first setting the objectives for targeted habitat attributes. Based on the targeted biological objectives that had been set, the subbasin planners then defined suites of strategies (or action types) that might be employed to achieve the objectives.

In contrast to ODFW's approach, the Walla Walla subbasin planning approach in 2004 only considered action effects at a 10-15 year time horizon. The action set for areas within Washington was comprised of the full suite of actions—including barrier removal (i.e., provisions for passage were made)—that were assembled for the subbasin plan. Because the Washington Walla Walla recovery plan only identified actions for a 10-15 year time horizon, we only modeled the response to actions for the 25 year timeframe and not for the 100 year timeframe.

Population performance as measured by both productivity and spawner abundance is increased markedly for all scenario combinations identified in this recovery plan, as well as, the aggregate actions of this plan and the Washington recovery plan. Relatively small differences exist between scenario results at 25 and 100 years. The largest contribution to performance

improvements is estimated to be due to tributary habitat actions. Benefits associated with mainstem actions are seen to be cumulative with the sequential addition of actions.

Viability thresholds are exceeded for all scenarios, including ones associated with a 25% decrease in marine survival. All scenario combinations result in threshold ratios between 1-3 for both productivity and abundance, suggesting a low risk of extinction over 100 years.

Table 10-46 and Figure 10-57 show projected changes in population performance of Walla Walla River summer steelhead populations associated with tributary and out-of-subbasin actions. Table 10-47 and Figure 10-58 show actions identified in this recovery plan. Projected changes in population performance of the Walla Walla River summer steelhead population associated with the tributary actions identified in this recovery plan and the Washington Walla Walla River steelhead recovery plan and out-of-subbasin actions.

Table 10-46. Estimated population performance (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. The results represent tributary actions that are described in this recovery plan and do not represent actions described in the Washington Walla Walla recovery plan area. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	1.34	650	0.99	0.65
B	C	B/C	1.60	864	1.18	0.86
P1-25	C	B/C	2.51	1,564	1.86	1.56
P1-25	Hyd	B/C	2.81	1,766	2.08	1.77
P1-25	Pred	B/C	2.94	1,844	2.18	1.84
P1-25	Est	B/C	3.10	1,946	2.30	1.95
P1-25	Har	B/C	3.10	1,946	2.30	1.95
P12-25	C	B/C	2.51	1,576	1.86	1.58
P12-25	Hyd	B/C	2.81	1,779	2.08	1.78
P12-25	Pred	B/C	2.94	1,859	2.18	1.86
P12-25	Est	B/C	3.11	1,961	2.30	1.96
P12-25	Har	B/C	3.11	1,961	2.30	1.96
P1-100	C	B/C	2.77	1,712	2.05	1.71
P1-100	Hyd	B/C	3.11	1,922	2.30	1.92
P1-100	Pred	B/C	3.24	2,004	2.40	2.00
P1-100	Est	B/C	3.43	2,110	2.54	2.11
P1-100	Har	B/C	3.43	2,110	2.54	2.11
P12-100	C	B/C	2.76	1,730	2.04	1.73
P12-100	Hyd	B/C	3.09	1,944	2.29	1.94
P12-100	Pred	B/C	3.23	2,027	2.39	2.03
P12-100	Est	B/C	3.41	2,136	2.53	2.14
P12-100	Har	B/C	3.41	2,136	2.53	2.14
P12-25	All	-25%	2.33	1,451	1.73	1.45
P12-100	All	-25%	2.56	1,599	1.90	1.60
P12-25	All	+25%	3.88	2,393	2.88	2.39
P12-100	All	+25%	4.27	2,590	3.16	2.59

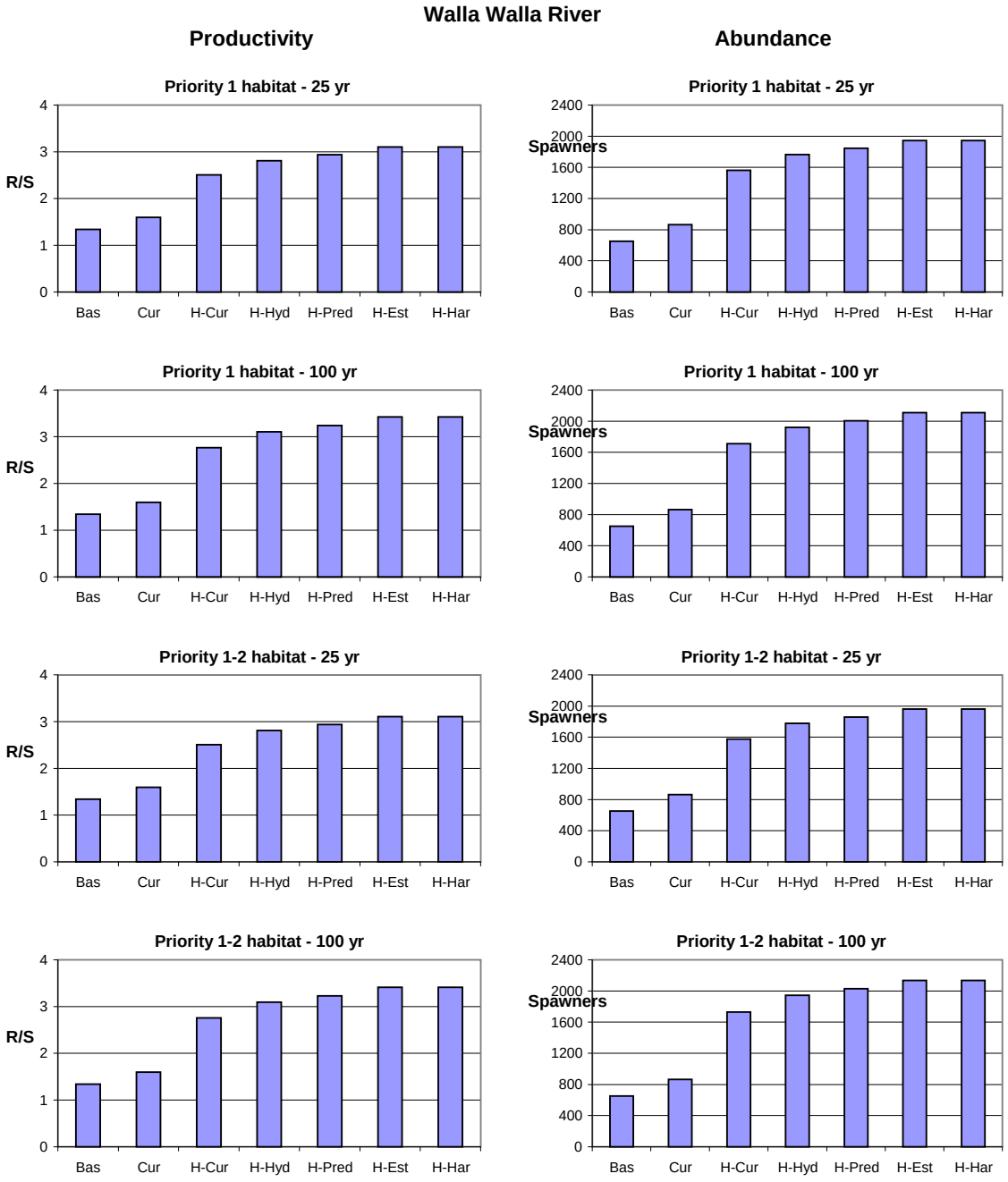


Figure 10-57. Estimated population performance measures (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary actions identified in the Oregon recovery plan and out-of-subbasin actions. See Table 10-36 for abbreviation definitions. Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

Table 10-47. Estimated population performance (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of-subbasin actions. Results are shown for actions performed on just Oregon lands (P12Ore) and with actions combined on Oregon and Washington lands (P12OreWa). Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. The threshold ratio is the ratio of the performance measure/ viability threshold level at the 5% level.

Scenario combination			Performance		Threshold ratio	
Tributary	Main/est	Ocean	Prod	Abund	Prod	Abund
B	B	B/C	1.34	650	0.99	0.65
B	C	B/C	1.60	864	1.18	0.86
P12Ore	C	B/C	2.51	1,576	1.86	1.58
P12OreWa	C	B/C	2.78	2,214	2.06	2.21
P12Ore	Hyd	B/C	2.81	1,779	2.08	1.78
P12OreWa	Hyd	B/C	3.12	2,515	2.31	2.52
P12Ore	Pred	B/C	2.94	1,858	2.18	1.86
P12OreWa	Pred	B/C	3.25	2,634	2.41	2.63
P12Ore	Est	B/C	3.11	1,961	2.30	1.96
P12OreWa	Est	B/C	3.44	2,790	2.55	2.79
P12Ore	Har	B/C	3.11	1,961	2.30	1.96
P12OreWa	Har	B/C	3.44	2,790	2.55	2.79
P12Ore	All	-25%	2.33	1,450	1.73	1.45
P12OreWa	All	-25%	2.58	2,033	1.91	2.03
P12Ore	All	+25%	3.88	2,392	2.88	2.39
P12OreWa	All	+25%	4.30	3,465	3.18	3.46

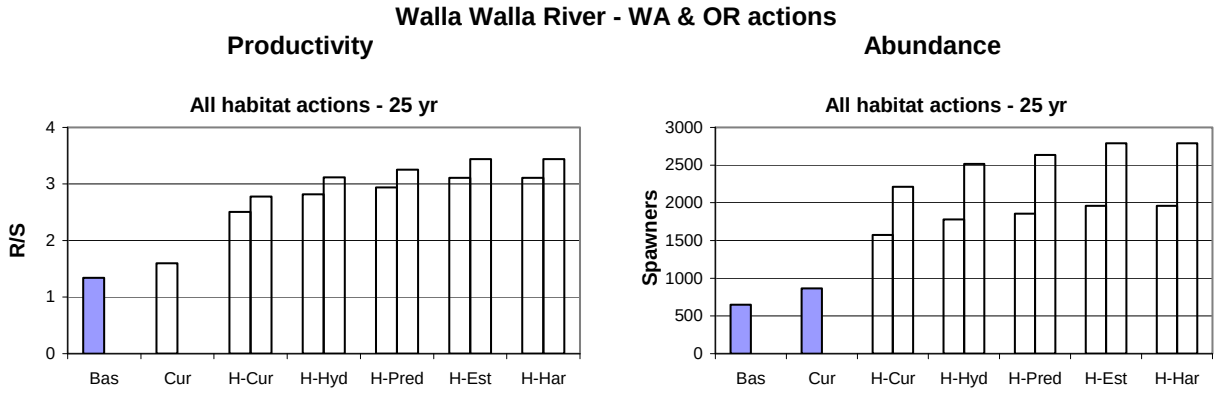


Figure 10-58. Estimated population performance measures (productivity and equilibrium abundance) of Walla Walla River summer steelhead associated with combinations of tributary and out-of-subbasin actions. Results are shown for actions performed on just Oregon lands (blue) and with actions combined on Oregon and Washington lands (red). Population performance measures are directly comparable to those derived empirically for baseline conditions by the ICTRT. Baseline, current, and combinations of tributary habitat scenarios (shown as H) with out-of-subbasin factors (Hyd, Pred, Est, Har) are shown.

10.4 All-H Management Action Effectiveness Analyses for Spatial Structure/Diversity

Fifteenmile Creek Population
There are no spatial structure or diversity gaps for the Fifteenmile Creek population. However, priority tributary habitat actions focus on restoring the natural hydrograph and reducing stream temperatures which are considered limiting factors. Improving these environmental conditions will allow for expansion of spawning distribution and expression of greater juvenile life history diversity, thus improving spatial structure and diversity status.

Deschutes River Eastside Population
Diversity is significantly impaired with gaps for phenotypic variation and spawner composition metrics. Reduced variability in both adult and juvenile migration patterns have likely occurred due to flow and temperature changes in Bakeoven, Buck Hollow, and Trout creeks, all of which are important production areas. Tributary habitat management actions target restoring the natural hydrograph and reducing stream temperatures. Restoring more normative flow patterns and reducing temperature will provide opportunity for more natural expression adult and juvenile migration patterns thus reducing risk ratings and improving viability.

Abundance of out-of-DPS stray hatchery spawners is a significant diversity impairment creating a high risk rating for the spawner composition metric. Management actions to reduce the abundance of stray hatchery spawners in this population include expansion of trapping and removal of hatchery fish in Trout Creek and initiation of trap and removal of stray hatchery fish in Bakeoven and Buck Hollow creeks. These actions are expected to significantly reduce the

proportion of spawners that are hatchery-origin fish in the population resulting in a lower risk rating for the spawner composition metric in the future.

Deschutes River Westside Population
The Deschutes River Westside population has gaps in both spatial structure and diversity. Spatial structure is significantly impaired because a substantial proportion of the spawning habitat is blocked by the Pelton-Round Butte Complex. This blockage results in spatial structure gaps for multiple metrics including spatial extent/range of spawning and increase in gaps between spawning aggregates. Management actions are underway to provide passage upstream and downstream at the dam complex and to reintroduce steelhead using Westside Deschutes stock to re-establish sustained natural production throughout the historic distribution. These actions, if successful, will result in reducing the risk ratings and improving viability.

Abundance of out-of-DPS stray hatchery spawners and genetic variation are significant diversity impairments. The high proportions of hatchery spawners results in a high risk rating for the spawner composition metric and genetic samples show moderate to low differentiation from outside-basin hatchery samples. Management actions to reduce abundance of out-of-basin hatchery spawners include continuation of trap and removal of strays at Warm Springs hatchery and initiation of trap and removal at Shitike Creek. These actions are expected to significantly reduce abundance of hatchery spawners and improve the diversity metric ratings in the future.

Lower Mainstem John Day River Population
Life history diversity, genetic variation and spawner composition are all metrics that have gaps for this population. Juvenile life history diversity has been reduced as a result of flow and temperature changes. Abundance of out-of-DPS spawners has resulted in a high risk rating for spawner composition. There are many tributary habitat actions that target restoring natural processes and improving both flow and temperature for the long term. These actions are expected to provide opportunity for expression of broader life history diversity. There are no specific actions proposed within this population to reduce abundance of out-of-DPS hatchery strays. However, we expect that if transportation of Snake River hatchery smolts is reduced in the future, and if some alternative broodstock are used for Snake River hatchery programs in the future, that the number of hatchery strays in this population will be reduced.

North Fork John Day River Population
The spatial structure/diversity gap for the North Fork population is spawner composition. Although there is a high degree of uncertainty associated with the proportion of hatchery spawners in this population this metric was rated high risk. No within-population actions are proposed to reduce out-of-basin hatchery stray abundance; however, reduced transportation of Snake River hatchery smolts and broodstock reform in Snake River hatchery programs may reduce abundance of strays in the future.

Middle Fork John Day River Population
All spatial structure/diversity metrics were rated low except spawner composition which was high risk due to abundance of out-of-DPS strays. No within-population management actions are proposed to reduce stray abundance. See the Lower Mainstem description of potential Snake River transportation and hatchery actions that may reduce strays.

South Fork John Day River Population
All spatial structure/diversity metrics were rated low except spawner composition which was high risk due to the proportion of out-of-DPS stray hatchery spawners. No within-population management actions are proposed to reduce the abundance of stray hatchery fish. See the Lower Mainstem description of potential Snake River transportation and hatchery actions that may reduce strays.

Upper Mainstem John Day River Population
Life history diversity and spawner composition are metrics that have gaps for this population. Juvenile movement patterns and reduced summer rearing distribution have likely resulted from altered tributary and mainstem habitats. There are many tributary habitat actions that target restoring natural processes with focus on reducing temperature, improving riparian condition, and increasing flow. These actions are expected to improve habitat conditions and result in opportunity for greater life history expression. The spawner composition metric was rated high risk due to abundance of out-of-DPS hatchery strays. No within-population management actions are proposed to reduce stray abundance. See the Lower Mainstem description of potential Snake River transportation and hatchery actions that may reduce strays.

Umatilla River Population
The Umatilla River population, along with the Walla Walla River population, has the greatest extent of spatial structure/diversity impairment of all Oregon's Mid-C populations. Both spatial structure and diversity have multiple metrics with substantial gaps. The current spawner distribution is significantly reduced from historical due to loss of spawning in Butter Creek and McKay Creek watersheds. Tributary habitat management actions in the Butter Creek watershed target improvement of passage, temperature and flow conditions which are the key limiting factors. These efforts, in the long term, will restore conditions and provide the potential for production in the future.

Four diversity metrics have gaps including life history, phenotypic variation, spawner composition and selective change in natural processes. Tributary management actions that target restoration of natural processes including reducing temperatures, improving the hydrograph, and improving riparian conditions will allow for broader expression of life history diversity including more normative adult and juvenile migration characteristics. These actions are expected to significantly reduce the diversity gaps. There are no Columbia River mainstem hydrosystem management actions proposed that will reduce the selectivity impacts of the hydrosystem.

Walla Walla River Population
The Walla Walla River population is one of Oregon's Mid-C populations with the greatest spatial structure/diversity impairments. Both spatial structure and diversity have multiple metrics with significant gaps. The current spawner distribution is reduced from the historic distribution due to loss of spawning in the Pine Creek watershed. Tributary management actions target restoration of natural processes and conditions, and actions within Pine Creek that focus on improving flow and water quality are considered high priority. Although, we expect that it will take a long time to restore Pine Creek to a condition that will allow sustained natural production. Restoration of sustained natural production in Pine Creek will significantly improve spatial structure with the population.

Four diversity metrics have gaps including life history, phenotypic variation, spawner composition and selective change in natural processes. Tributary habitat management actions target restoration of natural processes and include specific focus on the limiting factors causing diversity impairments. Actions focus on improving temperature, restoring natural hydrograph, and improving passage. These actions, although they will take a long time, will improve conditions and allow for more natural expression of life history diversity and phenotypic traits, such as adult and juvenile migration characteristics. There are no Columbia River mainstem hydrosystem management actions proposed that will reduce the selectivity impacts of the hydrosystem.

Section 11 Time and Cost Estimates

The ESA section 4(f)(1) requires that recovery plans include "estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal" (16 U.S.C. 1531-1544, as amended). This section and Appendix I are intended to meet this ESA requirement, and will be used by NMFS to estimate the total recovery costs for the Mid-Columbia steelhead DPS in its draft Mid-Columbia Steelhead DPS Plan.

11.1 Cost Estimates

The Oregon Department of Fish and Wildlife, together with its Recovery Planning Team, Management Action Teams, and the Oregon Mid-Columbia River Sounding Board have developed an extensive list of projects needed to recover the Oregon populations in the Mid-Columbia steelhead DPS. These projects are intended to address the recovery of ESA-listed Mid-Columbia River steelhead. This project list was developed using the most up-to-date assessment of Mid-Columbia steelhead recovery needs, without consideration of cost or potential funding. This section summarizes cost estimate findings and Appendix I provides cost estimates for recovery projects where available information was sufficient to do so. These draft cost estimates were prepared by a NMFS economist at the Northwest Fisheries Science Center in Seattle using a regional recovery cost database, together with input and review from ODFW, regional experts, and the Mid-Columbia Sounding Board in 2007.

Cost estimates for proposed recovery projects were developed using the unit cost method described in Appendix I. This involved: (1) grouping proposed recovery actions in Section 9 by project type; (2) determining the scale for each action; (3) developing unit costs for each project type and then calculating the total cost estimate for each project; and (4) the resulting total cost estimate by project was multiplied by 1.6 to reflect the additional costs of project planning, coordination, engineering, permits and other administrative needs. The multiplier was estimated after consulting with ODFW and other parties experienced in habitat restoration project implementation.

Table 11-1, Recovery Costs Summary Table, summarizes the total estimated cost for each strategy by population. The estimates are based on cost estimates in Appendix I, Table I-1 (*All Actions by Population, Strategy and Category*) that summarizes estimated total costs that can currently be identified for recovery actions in each Oregon population and strategy. No cost estimates are provided for (1) baseline actions (programs that are already in existence and would occur regardless of this recovery plan, or voluntary actions) that are listed as Not Applicable (N/A); and (2) for actions that need costs to be developed, need unit costs, and/or need project scale estimates, which are listed as To Be Determined (TBD). ODFW will work with regional experts to identify costs, scale or unit costs for actions that need more information during the public comment period. Appendix I will be updated with this new information for the final recovery plan.

The total estimated costs shown in Table 11-1 are by strategy and are either the Priority 1 and 2 estimated total stream mile costs or the estimated project costs in Appendix I, Table I-1. There are several cautions that must be highlighted regarding these summary costs, because many of these estimates may be incomplete until actions are better defined. For example, costs for potentially expensive projects such as land and water acquisition, water leasing, and RM&E have not yet been estimated for many populations. For other projects, unit cost estimates or determination of project scale may also still need to be calculated. Therefore, Table 11-1 presents preliminary summary costs, which will increase when unit cost estimates, scale of projects, and costs for actions are determined, for recovery of these populations.

The estimated total recovery costs in Table 11-1 range widely from relatively less expensive fish passage projects to more expensive projects such as restoring stream channel structure and complexity. The Lower John Day ($116,192,806) and Deschutes River Westside ($114,110,501) populations have the most expensive estimated total project costs, while the South Fork John Day ($8,656,103) and Fifteenmile ($28,358,906) populations have the smallest total costs. These total cost differences may be due to many factors such as size of the population's watershed, extent to which current conditions need to be improved, scale of projects, number of projects identified, and the availability of recovery action cost information by population at this time. The overall total cost estimate for all proposed actions where costs are available for all populations is $512,843,328.

Table 11-1. Recovery Costs Summary Table.

Population and Strategy	Total Estimated Cost
Fifteenmile Creek Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$480,000
3. Maintain and restore floodplain connectivity and function.	$7,760,314
4. Restore degraded and maintain properly functioning channel structure and complexity.	$17,090,583
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions	$2,852,009
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
Fifteenmile Total	**$28,358,906**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, Orchard Ridge and Wolf Run diversion piping, and upland vegetation management.	
Deschutes River Eastside Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$160,000
3. Maintain and restore floodplain connectivity and function.	$17,795,520
4. Restore degraded and maintain properly functioning channel structure and complexity.	$18,539,341
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$7,046,854
6. Restore natural hydrograph to provide sufficient flow during critical periods.	$197,702
7. Improve degraded water quality and maintain unimpaired water quality.	

Population and Strategy	Total Estimated Cost
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
Deschutes River Eastside Total	**$43,915,417**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, and upland vegetation management.	
Deschutes River Westside Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	
3. Maintain and restore floodplain connectivity and function.	$50,499,360
4. Restore degraded and maintain properly functioning channel structure and complexity.	$52,808,352
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$10,626,789
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
Deschutes River Westside Total	**$114,110,501**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, and forest road upgrading/removal.	
Lower Mainstem John Day River Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers.	$7,600,000
3. Maintain and restore floodplain connectivity and function and maintain unimpaired conditions.	$42,164,092
4. Restore degraded and maintain properly functioning channel structure and complexity.	$44,623,665
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$17,121,854
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	$4,507,195
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
Lower Mainstem John Day Total	**$116,192,806**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, push up dam removals, grazing management, and forest road upgrading/removal.	
North Fork John Day River Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$16,120,000
3. Maintain and restore floodplain connectivity and function.	$6,728,300
4. Restore degraded and maintain properly functioning channel structure and complexity.	$6,288,402
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$3,116,517
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	$1,704,357
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	$707,200

Population and Strategy	Total Estimated Cost
North Fork John Day Total	**$34,840,776**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, push up dam removal, and mine discharge management.	
Middle Fork John Day River Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$18,880,000
3. Maintain and restore floodplain connectivity and function.	$12,034,700
4. Restore degraded and maintain properly functioning channel structure and complexity.	$11,847,511
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$5,262,030
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	$1,489,614
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	$1,060,800
Middle Fork John Day Total	**$50,750,655**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, and push up dam removal.	
South Fork John Day River Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$5,680,000
3. Maintain and restore floodplain connectivity and function.	$551,660
4. Restore degraded and maintain properly functioning channel structure and complexity.	$481,353
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions	$1,234,920
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	$532,170
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
South Fork John Day Total	$8,656,103
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, push up dam removal, and forest road upgrading/removal.	
Upper Mainstem John Day River Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$12,240,000
3. Maintain and restore floodplain connectivity and function.	$11,891,318
4. Restore degraded and maintain properly functioning channel structure and complexity.	$15,855,724
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$5,731,272
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	$2,324,475
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	$104,000
Upper Mainstem John Day Total	**$48,322,789**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, and push up dam removal.	
Umatilla River Population	
1. Protect and conserve natural ecological processes.	$176,000

Population and Strategy	Total Estimated Cost
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$5,280,000
3. Maintain and restore floodplain connectivity and function.	$11,191,348
4. Restore degraded and maintain properly functioning channel structure and complexity.	$12,176,285
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$5,855,134
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
Umatilla Total	**$34,678,767**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, point source water pollution management, the Umatilla Basin Project, and forest road upgrading/removal.	
Walla Walla River Population	
1. Protect and conserve natural ecological processes.	$176,000
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain properly functioning passage and connectivity.	$3,520,000
3. Maintain and restore floodplain connectivity and function.	$9,786,240
4. Restore degraded and maintain properly functioning channel structure and complexity.	$14,696,304
5. Restore riparian condition and LWD recruitment and maintain properly functioning conditions.	$4,838,064
6. Restore natural hydrograph to provide sufficient flow during critical periods.	
7. Improve degraded water quality and maintain unimpaired water quality.	
8. Restore degraded and maintain properly functioning upland processes to minimize unnatural rates of erosion and runoff.	
Walla Walla Total	**$33,016,608**
Totals do not include actions with potentially significant costs to be determined later, including habitat acquisition, water right purchases, point source water pollution management, and forest road upgrading/removal.	
Grand Total	**$512,843,328**

Information on current expenditures and expected five-year budget amounts for habitat projects by a wide range of local, state, federal agencies and non-governmental organizations (NGOs) is provided in Appendix I, Table I-2 (*Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead*). This table provides context for the estimated costs of recovery actions and provides a basis for estimating possible levels of funding for recovery plan implementation over a given period of time. Total expected average expenditures over the next five years vary by population. For example, the Fifteenmile Creek population had the lowest expected total five-year expenditure ($3,550,000), while the Lower Mainstem John Day River population had the highest expected total five-year expenditure ($15,095,000). The total expected five-year expenditures for all populations is $103,537,000.

11.2 Time Estimate

NMFS estimates that recovery of the Mid-Columbia steelhead DPS, like recovery for most of the ESA-listed Pacific Northwest salmon and steelhead, could take 50 to 100 years. While this

recovery plan contains an extensive list of actions that need to be undertaken to recover Oregon's Mid-Columbia steelhead populations, there are many uncertainties involved in predicting the course of recovery and in estimating total costs. These include uncertainties regarding biological and ecosystem responses to recovery actions, as well as uncertainties regarding long-term and future funding. While continued programmatic actions in the management of habitat, hatcheries, hydro and harvest will warrant additional expenditures beyond the first 10 years, Oregon believes it is impracticable to estimate all projected actions and costs over 50 to 100 years, given the large number of economic, biological, and social variables involved. NMFS has a policy recommendation to focus on the first 10 years of implementation, with the proviso that before the end of this first implementation period, specific actions and costs will be estimated for subsequent years, to achieve long-term goals and to proceed until a determination is made that listing is no longer necessary.

Given the uncertainties in developing recovery cost estimates described above, Oregon is not able to estimate total or 10-year costs to recover Oregon's populations in the Mid-Columbia steelhead DPS. Table I-2, however, provides current average expenditures on habitat projects expected expenditures during the next five years. These projected five-year habitat project expenditures in Table I-2 total approximately $102 million.

In early 2008, Oregon will develop a plan for recovery project implementation, which will include project cost estimates, and identify how recovery plan implementation will be coordinated. This process is already underway as the Sounding Board discusses its future role in recovery plan implementation. Recovery costs will be revised in the future as specific project budgets are completed. The implementation plan will identify what entity or individual will carry out the recovery actions and the timeline for implementation.

Section 12 Implementation and Adaptive Management

12.1 Implementation

The successful implementation of the Oregon Mid-Columbia steelhead recovery plan recovery actions, research, monitoring and evaluation, and adaptive management process will require significant funds and the coordinated work of ODFW, State agencies, tribes, counties, irrigation districts, agriculture and private forest land managers, NMFS, U.S. Forest Service, BLM, other Federal agencies, local residents, citizen groups, utilities, other agencies, and individuals. ODFW, in coordination with the Oregon Governor's Office and NMFS, has taken the lead in developing this recovery plan; all will continue to be instrumental in its implementation. This section describes the overall framework for coordinated and cohesive implementation of the plan, including tracking, monitoring and reporting, as well as implementation of an adaptive management process.

The recovery plan identifies recovery strategies and actions using the best available science to address limiting factors and threats and recover Mid-C steelhead in Oregon. The NMFS interim recovery planning guidance (NMFS 1996) acknowledges that recovery plans are not regulatory documents, and that it is not a requirement of the ESA for any entity to implement the recovery strategy or specific actions in a recovery plan unless otherwise legally mandated. Consequently, this recovery plan is based primarily on voluntary implementation of proposed recovery actions as well as existing laws, regulations and agreements.

Many of the organizations which are currently implementing, and will implement recovery actions in the future, are not obligated to participate. The identification of an entity in the recovery actions does not necessarily require the identified party to implement the action(s) or to secure funding for implementing the action(s). It is anticipated that these organizations will choose to participate to advance their missions, as part of funding and contractual agreements, and in response to public education and outreach. In fact, there are many examples of voluntary recovery actions already being taken that support steelhead recovery. It is also acknowledged that there may be alternative actions to those proposed in this plan that may also attain recovery strategies. Actions to achieve a specific recovery strategy may vary due to logistics, funding constraints, or an organization's authorities and administrative processes.

Because of this large reliance on voluntary implementation of actions, public outreach and education will be a critical component of engaging citizens and communities to contribute to species recovery needs. Outreach and education will be conducted at all levels within the implementation framework, but will be most important at the local implementation level, specifically with watershed councils and soil and water conservation districts. Recovery plan outreach will be coordinated with outreach efforts under the Oregon Plan for Salmon and Watersheds. The public will also be invited to participate in meetings associated with recovery plan implementation. Without public interest, engagement and stewardship, the goals of this plan will not be achieved.

Oregon's recovery plan implementation framework is intended to provide a collaborative approach to implementation, science guidance and policy direction, as well as facilitate information exchange and coordination from local-level action entities to upper level decision makers and provide linkage to state, DPS and regional forums. Existing forums, groups, partnerships and involved citizens make this implementation structure possible, but additional resources and funding will be needed to make it work effectively and successfully. The basic components of Oregon's implementation framework include a Recovery Team, an Implementation Coordinator, an Implementation Team, a Technical Team, and Watershed Teams (Figure 12.1). These teams will interface with and potentially strengthen the various state agency teams associated with the Oregon Plan for Salmon and Watersheds that provide for policy, management, and monitoring of interagency Oregon Plan programs for the conservation and restoration of habitat, water quality, and salmon (http://www.oregon.gov/OPSW/). In addition, these teams will function to coordinate within the DPS implementation and adaptive management framework (Figure 12.2). The implementation framework will adapt and change as necessary to adjust to funding, available resources, and implementation needs. The roles of each of these implementation teams and the coordinator are described below.

Recovery Team: The Recovery Team provides oversight and vision to recovery plan implementation, in a similar role as the Mid-C Sounding Board served in the plan development process. This team is the responsible entity for reporting to NMFS and shares accountability for species recovery in this MU. The Recovery Team coordinates at state, federal and regional levels; makes decisions and acts on policy, funding and legislative needs; provides overall guidance to the recovery plan teams and coordinates with other domain teams and the Oregon Plan Core Team (interagency policy forum); and serves as the state's representative at the bi-state Mid-C Forum. Members of this team include representatives from the Oregon Governor's Natural Resources Office, ODFW (including the Implementation Coordinator), and the Oregon Watershed Enhancement Board. Additional membership will include interested parties from counties, tribes and federal agencies. While the Recovery Team serves a unique purpose and function, members of this Team will also be members of the Implementation Team.

Implementation Coordinator: An ODFW implementation coordinator will serve as Oregon's "MU lead" for recovery plan implementation, under the advice and guidance of the Recovery Team. The Coordinator will be a key connector to the various teams, groups, subgroups and individual entities. The Implementation Coordinator will work in conjunction with the Implementation Team and Watershed Teams to plan, schedule, track and report on action implementation, and in coordination with the Technical Team to develop, track and report on RM&E activities. The Implementation Coordinator will also be a member of the Recovery Team and a participant in the DPS Implementation and Outreach subgroups. If necessary, the Coordinator will communicate with local, state, federal or tribal hatcheries and other entities and agency staff that perform work related to anadromous fish in the MU. The Implementation Coordinator will lead the Implementation Team in its deliberations and actions, coordinate and lead annual implementation plan development and adaptive management processes, coordinate and communicate with Watershed Teams (or individual implementation entities) and the Oregon Plan Regional Management Teams (interagency regional manager forum). This MU lead will also integrate with regional forums for hydro, harvest and hatchery issues, including the FCRPS BiOp, US v OR, Northwest Planning and Conservation Council, and Columbia Basin Fish and

Wildlife Authority, through linkage with ODFW staff representatives in these forums. Actions and decisions within these forums are important for achieving successful plan implementation and recovery of Mid-C steelhead.

Implementation Team: The Implementation Team provides advice, recommendations and support to the Implementation Coordinator (chair). This Team assists in the communication and coordination with Watershed Teams or local implementation groups, development, tracking and reporting of annual implementation plans, and tracking and reporting of research and monitoring. The Implementation Team also facilitates gathering and exchange of information, identifies and pursues funding sources, and provides for public participation, education and outreach.

Team Members include members of the Mid-C Sounding Board (irrigation districts, utilities, conservation groups, federal and tribal representatives, watershed councils, SWCDs) and other local stakeholders, interest groups and governments. This diverse group represents differing perspectives, missions, and geographic areas, with the overall objective of collectively and synergistically working together to achieve and advance recovery plan goals. The Implementation Team will be staffed by a facilitator and a NMFS representative.

Technical Team: The Technical Team provides advice and guidance on technical and science issues related to monitoring, research and evaluation, data analysis, and adaptive management that supports and strengthens effective implementation of recovery plan actions. The Team will provide the framework for data and dataset gathering from diverse sources and the data management and analysis necessary for threats and viability assessments of the MPG populations. The Oregon Plan Monitoring Team (interagency monitoring forum) will interface with the Technical Team. The Technical Team will be an important MU link to the Mid-C Forum RM&E subgroup, participating in DPS status reviews and ensuring consistency in monitoring. A member of the Technical Team will serve on the Implementation Team. Members of the Technical Team will include members of the recovery plan Planning Team and Expert Panel, as well as other key state, federal, tribal, utility and private scientists and biologists, consultants, and university staff. A voluntary chair will facilitate team operations until funding can be obtained to provide remuneration.

Watershed Teams: Watershed Teams are comprised of the various local entities implementing local restoration and conservation actions via their respective authorities, mandates, missions, and work plans, and include watershed councils, SWCDs, federal and state agencies, local governments, tribes, conservation groups, and utilities. Watershed Teams will be encouraged and facilitated to form on a voluntary basis for a specific watershed, or will be collaborative partnership forums already in existence. In many cases, watershed councils currently serve this function with representation from a diversity of interest and action groups. Team chairs will be voluntary and teams will be self-directed. Collaborative teams will facilitate coordination and prioritization of actions and exchange of information within the watershed. They will provide project information to the Implementation Coordinator (or members of the Implementation Team) to support development of annual implementation schedules, plans, and reports. Collectively or individually, Watershed Teams will promote public involvement through outreach, education, and volunteer opportunities.

The Watershed Teams represent the Major Population Groups in the Oregon Mid-C MU, to include the Cascade Eastern Slopes MPG, the John Day MPG, and the Umatilla/Walla Walla MPG. However, each MPG will include two or more teams representing various populations in the MPG.

Cascade Eastern Slopes MPG: Deschutes Westside (to include Fifteenmile Creek) and Deschutes Eastside populations
John Day MPG: Lower Mainstem, North Fork, Middle Fork, South Fork, and Upper Mainstem John Day populations.
Umatilla/Walla Walla MPG: Umatilla and Walla Walla populations.

If Watershed Teams are not formed, the Implementation Coordinator and members of the Implementation Team will work with individual action entities in the watershed, as necessary.

Oregon will participate in the newly formed bi-state steelhead DPS-level Mid-Columbia Forum to ensure Oregon steelhead implementation activities are coordinated with recovery work in the other steelhead DPS management units in Washington, which are coordinated by local recovery boards (i.e., Yakima and Snake River). Oregon's Recovery Team (through its leads) and Washington's recovery boards (through their executive directors or leads) will be responsible for reporting progress to the Mid-Columbia Forum and NMFS on an annual basis, including progress in management, conservation, and research, monitoring and evaluation actions, and trends in habitat health and salmonid viability.

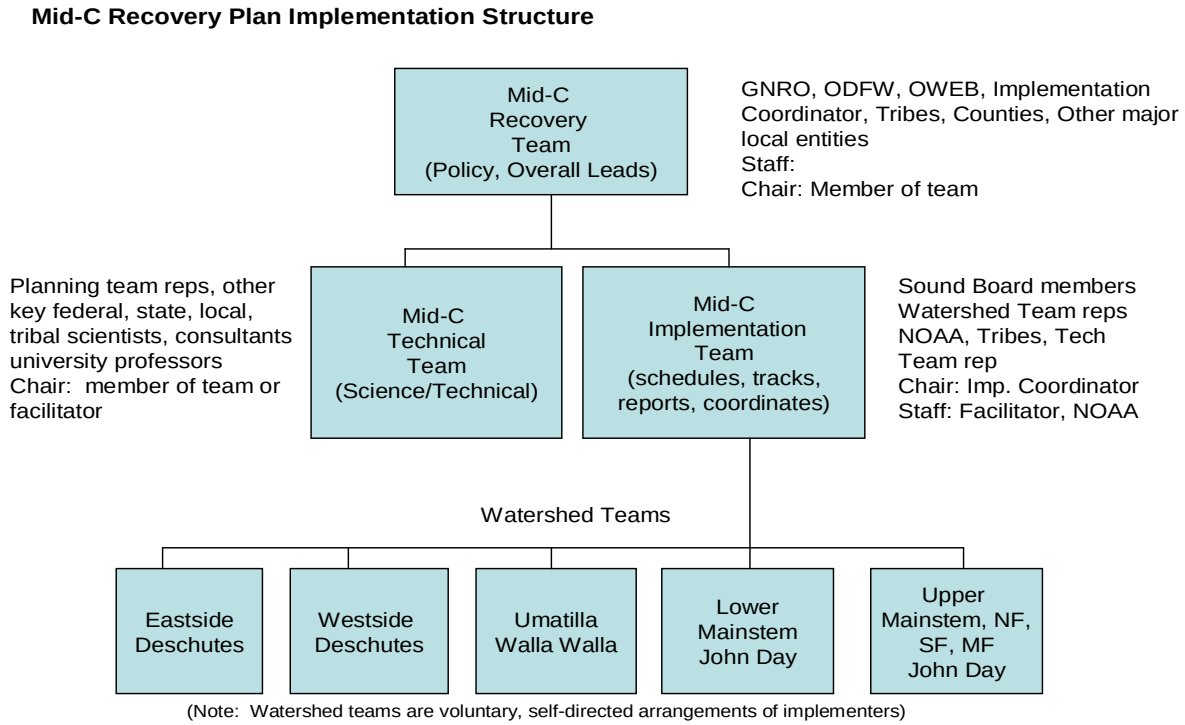


Figure 12.1. Implementation and adaptive management organizational chart for Oregon's Mid-C Steelhead Recovery Plan.

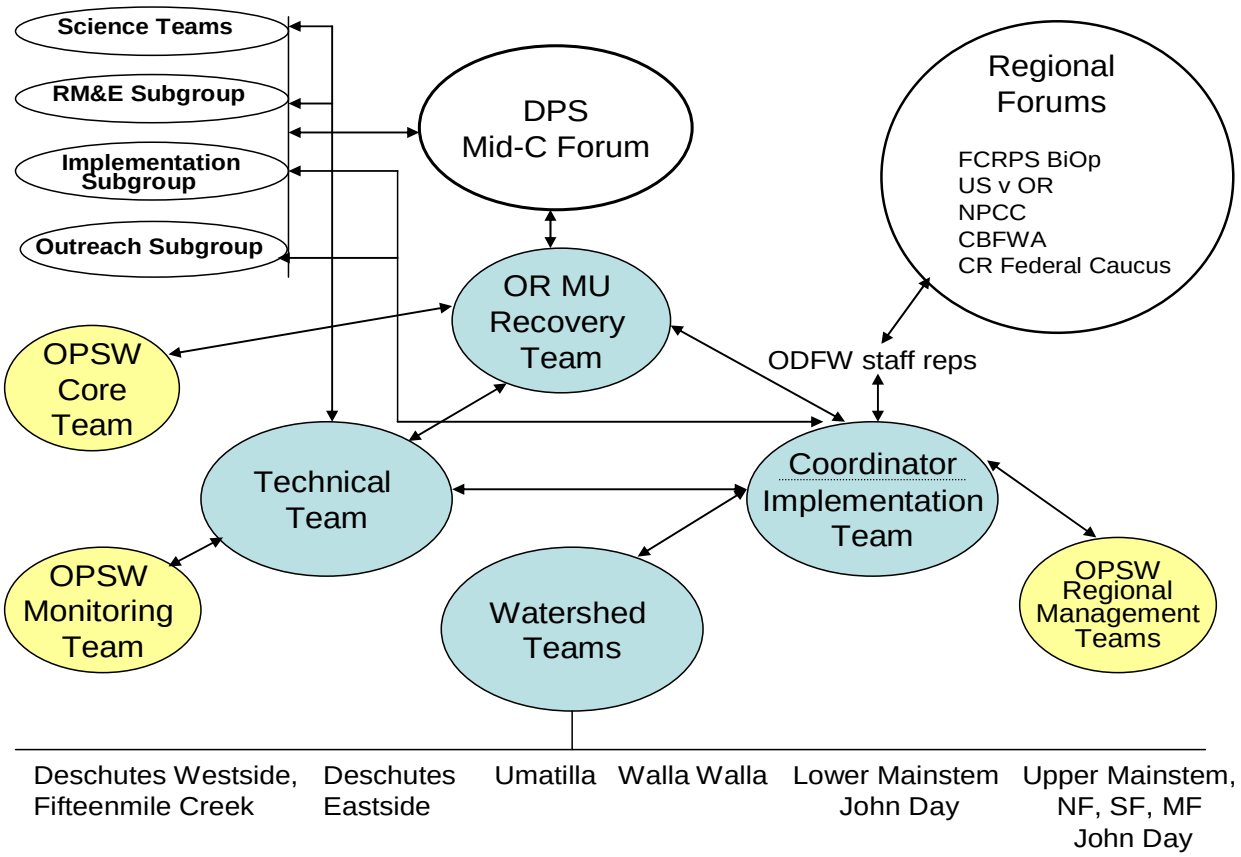


Figure 12.2. Implementation and adaptive management organizational chart for the Mid-C DPS Steelhead Recovery Plan including the Oregon components.

Oregon and NOAA will produce an implementation plan with a schedule to satisfy the requirement under the ESA. The detailed implementation plan will serve as the guidance document that describes the time-specific implementation of actions for all programs. The implementation plan will serve as the benchmark of expected milestones that allows for tracking of progress in recovery plan action implementation.

An ESA implementation plan identifies the following:

- recovery actions,
- priority for completing the actions,
- timeline and duration for completion of the actions,
- lead agency/entity to implement each action, and
- estimated cost for each action over a specified period of time.

Many of the elements of the detailed implementation plan are already covered in this recovery plan including actions, priorities, and program responsibility. The principle element that is missing is the program by program description of actions that will be completed on an annual basis. A detailed implementation schedule and plan will be completed in 2009 after Oregon and NMFS have refined and finalized the proposed recovery actions and recovery costs based on

public comments and the recovery plan is adopted in 2009. In developing this implementation plan, Oregon and NMFS will work with Oregon's Implementation Team, and in close association with the Oregon Plan Regional Management Teams (Central Regional Management Team and Eastern Regional Management Team), to identify who is responsible for carrying out recovery actions and when. Federal agencies will also need to identify how they will be involved in recovery plan implementation.

12.2 Adaptive Management

Mid-C steelhead have a complex life cycle that traverses habitats from high elevation tributaries to the open ocean. Life history strategies and life stage specific habitat requirements are complex. There are many limiting factors and threats that influence the viability of Oregon's Mid-C steelhead at all life stages. The suite of proposed management actions to address primary limiting factors and threats across the entire life cycle is extensive and diverse. Although the limiting factors and threats, as well as the management actions, have been developed based on the best available science, there remains considerable uncertainty regarding the outcomes and effectiveness of the proposed management actions as well as the status of the populations. It is this uncertainty which generates the essential need for an effective adaptive management process.

A successful adaptive management process requires that we understand how and why steelhead and their associated habitats respond to the management actions we take to address key limiting factors and threats. In addition, success requires a decision framework and process which considers new information in the development and implementation of future management actions.

One of the great challenges facing the development and implementation of an effective adaptive management strategy for Oregon's Mid-C steelhead is the extensive number of organizations that implement management actions, as well as the complexity in jurisdictional and management decision authority. There are many different organizations including state agencies, tribes, counties, irrigation districts, agriculture and private forest land managers, NOAA, U.S. Forest Service, BLM, other federal agencies, local residents, citizen groups, utilities and others that implement management actions.

Along with this implementation complexity is a parallel level of jurisdictional, management decision authority, and process complexity. There is no one single decision body that holds decision authority for management actions across all the H's. Decision authority for management actions resides across many entities including state, tribal, federal, county as well as others. Those diverse decision frameworks and processes, many independent of others, create coordination and collaboration challenges. We acknowledge that it is unreasonable to expect centralization and integration of all authorities and decision processes into a single decision framework. Our approach is to develop a collaboration and coordination process that uses the implementation structures and allows for sharing of information and decisions that influence recovery of Mid-C steelhead.

Integration of the many adaptive decision processes will occur within the adaptive management framework illustrated in Figure 12.1. The Recovery Team and the Implementation Team will serve key roles in incorporating new knowledge into future management guidance and direction. These teams will not only provide input for adaptive implementation of tributary habitat actions, they will also provide input into other regional decision forums through the Mid-C Forum and State of Oregon representatives.

In the following text, we provide a description of the various management decision processes and associated adaptive management plans that influence management actions for tributary habitat, mainstem hydrosystem, harvest and hatcheries.

12.2.1 Tributary Habitat

There is a variety of funding sources and implementing entities responsible for tributary habitat restoration actions. In all cases the funding sources and implementing entities have adaptive decision processes for prioritizing actions. It is beyond the scope of this document to present all of the processes used, thus, we provide a few examples illustrating the major ongoing decision processes, followed by a description of how the recovery plan adaptive management framework will address adaptive management for tributary habitat protection and restoration.

The Oregon Watershed Enhancement Board (OWEB) is a state agency that supports Oregon's efforts to improve water quality, strengthen ecosystems and restore salmon runs. OWEB coordinates the Oregon Plan for Salmon and Watersheds, which is an essential element of tributary habitat restoration for the recovery plan. OWEB administers grant funding programs from Oregon lottery proceeds and from federal Pacific Coastal Salmon Recovery Funds (PCSRF). These grant programs fund cooperative salmon habitat restoration for a wide variety of implementers. OWEB's strategic plan describes how the board will achieve watershed restoration. OWEB focuses on projects that approach natural resource management with a whole-watershed perspective through investments and partnerships. Priority watershed concerns addressed by grants include:

- Instream Process and Function
- Fish Passage
- Urban Impact Reduction
- Riparian Process and Function
- Wetland Process and Function
- Upland Process and Function
- Water Quantity/Irrigation Efficiency
- Road Impact Reduction

An essential element of the OWEB strategy is active implementation of adaptive management. Adaptive management is implemented in a variety of ways through strategic guidance, project review, selection and prioritization processes and emphasis on monitoring and evaluation. Review team members score and discuss applications to determine which projects to recommend for funding.

Monitoring information from the complement of different types of project monitoring efforts (e.g., baseline, compliance, status and trend, effectiveness, and validation monitoring) and the cooperative interagency Monitoring Team is used to help measure project progress and effectiveness. Oregon is able to document watershed conditions, track changes in critical habitat and species over time, and evaluate the effectiveness of conservation and restoration efforts. This diversity of monitoring approaches is essential to understanding watershed health, tracking the success of projects, and setting restoration priorities.

As a critical element in the grant funding process, the OWEB Board is kept apprised of new and emerging issues in the natural resources arena to help guide their decisions. As an example, the Board has received many presentations on climate change and its potential impacts to watersheds and salmon. This information helps to shape the decision framework within which the Board operates and its final recommendations. The OWEB Board has provided general recommendations as guidance for grant funding and overall action implementation in the watershed to strengthen the Oregon Plan for Salmon and Watersheds:

- Promote citizen involvement in the Oregon Plan
- Build creative partnerships to focus on significant ecological outcomes
- Streamline and expedite permitting for restoration projects
- Support strong leadership, interagency communication, and coordination
- Develop and implement shared priorities for restoration
- Track restoration and recovery trends and improve information accessibility
- Develop a coordinated strategy that demonstrates ways habitat restoration actions reduce the growing risk of climate change

The Northwest Power and Conservation Council's Columbia Basin Fish and Wildlife Program provides extensive funding to many habitat protection and restoration implementers in all of Oregon's Mid-C steelhead populations. The Fish and Wildlife Program was established to mitigate the effects of the Columbia River federal power system. On a periodic basis (typically every three years), the NPCC solicits and evaluates proposals for on-the-ground monitoring and evaluation projects to meet the goals and objectives of the program. Proposed projects undergo a rigorous scientific review and revision process to ensure implementation of sound and effective high priority projects that are based on best available science and use state-of-the-art restoration strategies and approaches. Integral to this process is the review of each individual proposal by the Independent Science Review Panel (ISRP). Each project is evaluated, in part, based on the project's role in contributing to an effective adaptive management process. The review process has resulted in significant changes through time in implementation strategies and actions for most habitat restoration projects.

SWCDs, Watershed Councils, and other habitat restoration implementation entities all have prioritization and adaptive change processes that are used in deciding which projects to implement. New monitoring and evaluation information is used within each of these decision frameworks to decide on priority actions, geographic locations, and specific applications. Within these processes the consideration of high priority recovery actions is important.

Although OWEB, NPCC, SWCDs, tribes, states, NGOs and others have prioritization processes and elements of adaptive management, there is a clear need for a more integrated and coordinated adaptive management approach for tributary habitat restoration. Previously in this section we described an implementation and adaptive management framework for this recovery plan. We do not envision this new framework and process to replace the other processes that are currently used, but rather a mechanism to improve collaboration, coordination and sharing of essential information for decision making. Under the guidance of the Recovery Team and the Implementation Team, the Technical Team and Implementation Coordinator will function as the core for tributary habitat adaptive management. New information, including successes and failures, will be shared throughout the framework from the watershed and technical teams upwards to the Recovery Team to allow for better decisions regarding priority actions, geographic focus areas, and application techniques. The Oregon Plan Regional Management teams play an important role in this adaptive process as they hold responsibility for managing the implementation and prioritization of many critical restoration actions.

12.2.2 Mainstem Hydrosystem

Implementation Plans and Reporting Requirements
The FCRPS BiOp requires the federal Action Agencies to continue collaboration with states and tribes in the implementation of Reasonable and Prudent (RPA) actions, progress reporting, and adaptive management using regional fora such as the Regional Implementation Oversight Group. RPA Actions 1 through 3 identify the general requirements governing the federal Action Agencies' development of implementation plans and reporting requirements. The federal Action Agencies must submit implementation plans to NOAA Fisheries in December of 2009, 2013, and 2016 that detail commitments to implement RPA actions - during subsequent years - for hydro, habitat, hatcheries, harvest, and predation (RPA Actions 4-49), and RPA actions (50-73) for Research, Monitoring, and Evaluation (RM&E).

The federal Action Agencies are required to submit Annual Progress Reports to NOAA Fisheries September 2009 through 2018 which cover hydro operations, status of physical or biological metrics monitoring, and actions implemented in the previous year, except in 2013 and 2016.

In June of 2013 and 2016, the federal Action Agencies are required to submit Comprehensive RPA Evaluation Reports to NOAA Fisheries. These reports shall review all implementation activities through the end of the previous year (as covered in the Annual Progress Reports) and compare them to scheduled completion dates in the BiOp or as modified through the Implementation Plans in 2009, 2013, and 2016. The Comprehensive RPA Evaluation will also describe the status of the physical and biological factors identified in the RPA, and compare these with the expectations in the survival improvements identified in the Comprehensive Analysis or Supplemental Comprehensive Analysis. Physical and biological factors will include new information on climate change and its effects on listed salmon and steelhead. The Comprehensive Evaluation will include a discussion of the Action Agencies' plan to address any shortcomings of current estimated survival improvements as compared to the original survival estimates identified in the Comprehensive Analysis referenced in the 2008 FCRPS BiOp.

RM&E Requirements

The 2008 FCRPS BiOp includes some research, monitoring, and evaluation (RM&E) requirements (Reasonable and Prudent Alternative Actions 50 through 73) for the federal Action Agencies (U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Bonneville Power Administration). These RM&E requirements are designed to provide information needed to support planning and adaptive management and demonstrate accountability related to the implementation of FCRPS ESA hydropower and offsite actions for all ESA-listed species (Evolutionarily Significant Units or Distinct Population Segments). Considerably more detail in the RM&E plans needs to be developed in the early stages of BiOp implementation. The 24 RPA actions can be categorized into nine broad strategies:

1. Monitor Status of Selected Fish Populations Related to FCRPS Actions
2. Hydropower RM&E
3. Tributary Habitat RM&E
4. Estuary and Ocean RM&E
5. Harvest RM&E
6. Hatchery RM&E
7. Predation Management RM&E
8. Coordination and Data Management
9. Project Implementation and Compliance Monitoring

Regional Implementation and Oversight Group and Technical Committees

Regional Implementation and Oversight Group (RIOG)

As described in the BiOps and related documents, the RIOG is established to provide a high level policy forum for discussion and coordination of the implementation of the FCRPS and related BiOps between the federal agencies on the one hand and states and affected tribes on the other hand. The overall purpose of the group is to inform federal, state and tribal agencies that are actively engaged in salmon recovery efforts regarding implementation issues from each sovereign's perspective. In doing so, the RIOG will serve as a forum where Basin-wide policy issues and concerns related to the implementation of the BiOps, including impacts on other Basin-wide basin programs and interests may be discussed in a collaborative manner, and to provide a forum for enhanced accountability and transparency.

The RIOG will consist of designated senior policy representatives of each of the following:

- five regional federal agencies: NOAA, BPA, Reclamation, Corps and the US Fish and Wildlife Service;
- four state governors: Montana, Idaho, Washington and Oregon; and
- Colville, Spokane, Kootenai, Warm Springs, Umatilla, Yakama, Nez Perce, Kalispel and Salish-Kootenai tribal governments (all Columbia Basin Tribes are invited to participate).

However, no agency or sovereign is compelled to participate in the RIOG because participation is by interest and choice. Some sovereigns may not have enough interest in implementation of the BiOps to warrant participation.

All decisions under the authority of the federal government will continue to be made by the appropriate federal agency with the statutory authority to make such decisions. The RIOG is a forum for interagency coordination and does not supplant existing federal, state or tribal decision-making authorities.

Technical Committees

The RIOG will be supported (groups should form in 2009) by Senior Technical Teams for hydro, habitat, hatcheries, and RM&E integration (the latter as needed) and by additional Technical Teams. The Technical Teams will include groups that have been used in the past (Technical Management Team, System Configuration Team, Water Quality Team, Corps of Engineers workgroups, etc.), as well as, new teams (geographically based Habitat and Hatchery Teams and a Predation Management Team) that will be formed in 2009. Technical information and recommendations will flow "upward" from the Technical Workgroups to the Senior Technical Workgroups to the RIOG (for adaptive management and dispute resolution) and policy guidance and technical assignments will flow "downward" from the RIOG to the Senior Technical and Technical level groups.

Together, these RIOG and Technical Committees will attempt to assure that actions required by the 2008 FCRPS BiOp are effectively implemented, performance standards are achieved, disputes are resolved, and other regional processes (NOAA Fisheries' recovery plans, US v. Oregon, Northwest Power and Conservation Council's Fish and Wildlife Program, etc.) are fully considered during the 10-year implementation of the 2008 FCRPS BiOp.

12.2.3 Harvest

Mainstem Columbia River

The parties to the *2008-2017 United States v. Oregon Management Agreement* recognize that a vigorous research and monitoring program is essential to the continued implementation and adaptive management of the harvest regimes that are envisioned in the agreement. The objective of the proposed research and monitoring is to improve the accuracy and precision of harvest management. Specific monitoring and research needs to provide information which is essential for adaptive management are identified in the agreement, and include:

- Fisheries sampling for stock composition including impacts to natural-origin fish
- Fishery effort accounting
- Natural spawning escapement enumeration including enhancements over current sampling efforts
- Run reconstruction and forecasting
- Observer programs and test fisheries
- Dam passage sampling
- PIT tag sampling
- Increased sampling effort to maintain necessary fishery sampling rates
- Evaluation of genetic stock identification methods to further improve stock identification

A Technical Advisory Committee (TAC), comprised of fishery biologists from state, federal and tribal management agencies, is established by the agreement to develop, analyze, and review data pertinent to the agreement and to make reports and technical recommendations regarding harvest management.

The parties to *US v. Oregon* agreed to work together to maintain funding for current research and monitoring programs, and to seek additional funding that are considered essential to increase certainty in the conservation effectiveness of the harvest strategies contained within the agreement. The parties also agreed to seek funding sources to assist TAC and its representatives in the performance of their functions.

Additional monitoring, evaluation and adaptive management of harvest is provided by the Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on Treaty Indian and Non-Indian Fisheries in the Columbia River Basin Subject To the 2008-2017 *US v. Oregon* Management Agreement (hereafter, Fisheries Biological Opinion). The Fisheries Biological Opinion was approved by NOAA Fisheries on May 5, 2008. Section 13.4 of the Biological Opinion specifically identifies several Reasonable & Prudent Measures that emphasize in-season management actions that will ensure that incidental take of ESA-listed species, including of listed steelhead, remain consistent with the Biological Opinion. These measures specifically require that:

- Harvest impacts on listed species shall be monitored using the best available measures;
- In-season management actions taken during the course of fisheries managed pursuant to the 2008 *US v. Oregon* Agreement shall be consistent with the level of take specified in the Incidental Take Statement in the Fisheries Biological Opinion;
- NOAA Fisheries shall consult with the states and tribes to account for the catch of ESA-listed steelhead in the action area as these occur through the season; and
- NOAA Fisheries will track the results of these monitoring activities, and in particular, any anticipated or actual increases in the incidental take from those expected preseason.

Recreational Fisheries Regulation Processes (ODFW)
The procedures for promulgation of angling regulations in accordance with Oregon Revised Statute 496.162 are described in Oregon Administrative Rule 635-011-0050. This rule states that "Department staff shall continually monitor the status of fish, shellfish, and marine invertebrates and report promptly to the Director and Commission any serious or abnormal changes in health or abundance of the resource." There are three basic rule making processes used to develop angling regulations which are described below.

The "Public Process" solicits proposals for new or modified angling regulations from the public and considers these proposals for adoption along with ODFW staff proposals. The public process takes place on a four-year cycle, with the last Public Process completed for the 2009 Oregon Sport Fishing Regulations. The Public Process takes over a year to execute with staff proposals solicited 16 months before rule adoption.

During the "Interim Years" angling regulation changes are adopted without substantive changes, but there are opportunities to make rule changes to meet conservation needs, and to make any corrections or clarifications. Rules developed as part of Fish Management Plans are also considered during Interim Years. The "Interim Year" process normally begins in late April when Fish Division Staff solicit rule changes from Fish District Biologists and Fish Division Management. Rules are then adopted in August and take effect January 1 of the following year.

Angling regulations can also be changed by "Temporary Rules" (often referred to as emergency rules) which are put in place to: protect or preserve a fish species or stock experiencing depletion or drastic decline in health or abundance, or to allow anglers to harvest stocks of fish that become more abundant than expected. Temporary Rules are approved by the ODFW Director and can be put in place within 24 hours. The Commission must reaffirm the Temporary Rules at the next scheduled Commission meeting. Temporary Rules are good for up to 6 months, but any temporary rule needing to be in place longer should be adopted as a permanent rule prior to the 6-month time period.

Fisheries Management and Evaluation Plans

Under Limit 4 of the 4(d) rule (U.S. Office of the Federal Register 2000), take prohibitions do not apply to activities associated with fishery harvest activities, provided that the fisheries are managed in accordance with a NMFS-approved Fisheries Management and Evaluation Plan (FMEP) that is implemented in accordance with a letter of concurrence from NMFS. The FMEP, to be approved, must meet a number of specified criteria described in the rule. A template has been adopted for development of FMEPs that meet the required criteria (NMFS 2000).

To provide for adaptive management, Section 3.5 of the FMEP template requires the applicant to include a schedule and process for reviewing and modifying fisheries management under the FMEP (NMFS 2000). The FMEP template calls for two evaluation review processes to be identified in the FMEP (1) a regular review of fisheries (e.g., annually) and (2) a comprehensive assessment of the overall effectiveness of the FMEP (e.g., every one or two full brood cycles, depending on the listed species). The FMEP evaluation must assess the effectiveness of the FMEP in accomplishing the stated objectives over a longer period of time. This evaluation would take into account any new information that may require revisions in assumptions or management strategies (NMFS 2000).

The FMEP shall describe the process and schedule that will be used on a regular basis (annually) to evaluate the fisheries, and revise management assumptions and targets if necessary. The annual evaluation should provide (1) summaries of mortality, effort, escapement, and biological data, and (2) how well management performed in meeting the desired management targets by population (or management unit). Specific annual reporting requirements are described in the concurrence letter from NMFS to the applicant (NMFS 2000).

The FMEP shall also include a description of the process and schedule that will occur every 5 years (or one or two brood cycles), to evaluate whether the FMEP is accomplishing the state objectives. The conditions under which revisions to the FMEP will be made and how the revisions will likely be accomplished are to be included in this section. The FMEP

comprehensive evaluation must provide (1) summaries of population or management unit status relative to delisting and broad sense recovery goals at the beginning and end of the period under review; (2) a summary of the status of the ESU/DPS at the beginning and end of the period under review; (3) performance review of each element of the FMEP relative to its specific existing and any subsequent newly defined standards; (4) estimates of precision and confidence for the analyses conducted above; and (5) recommendations pertaining to management objectives, strategies, and actions including possible modification or termination of existing measures and addition of new ones (NMFS 2000).

In addition to the processes described above, NMFS requires that the fisheries managers notify and provide to NMFS any proposed fishery regulation changes that affect fisheries within the FMEP. NMFS will evaluate the proposed changes to determine if they constitute additional impacts that were not contemplated during the review and evaluation of the submitted FMEP. Depending on the species and fishery involved, these regulation changes can occur annually or in-season.

12.2.4 Hatcheries

Hatchery Scientific Review Group (HSRG)
The HSRG completed review and recommendations for all populations and hatchery programs in the Oregon portion of the Mid-Columbia Steelhead DPS. In Section 9, we characterized the HSRG recommendations and the consistency between the recovery plan actions and HSRG recommendations. In all cases, the HSRG recommendations were consistent with what had been proposed in the 2007 draft recovery plan released for public comment.

Hatchery and Genetics Management Plans
Under Limit 5 of the 4(d) rule (65 FR 42422 July 10, 2000), take prohibitions do not apply to activities associated with artificial propagation programs, provided that a Hatchery and Genetics Management Plan (HGMP) has been approved by NMFS as meeting a list of criteria that are specified in the rule. To provide for adaptive management, the HGMPs need to provide adequate monitoring and evaluation to detect and evaluate the success of the hatchery program and any risks potentially impairing the recovery of the listed ESU/DPS. Furthermore, the HGMPs need to provide for the evaluation of the monitoring data and include the potential to revise the assumptions, management strategies, or objectives that data show are needed. As part of the letter of concurrence, NMFS will describe the implementation process and reporting requirements, including annual production reports and the evaluation of monitoring data.

Limit 5 of the 4(d) rule requires NMFS to evaluate on a regular basis the effectiveness of the HGMP in protecting and achieving a level of salmonid productivity commensurate with the conservation of the listed salmonids. If the HGMP is not effective, NMFS will identify to the operators ways in which the program needs to be altered or strengthened.

The evaluation of the effectiveness of the HGMPs could lead to the reinitiation of the hatchery consultation if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the hatchery actions that may affect listed species or critical habitat in a manner or to an extent not considered in the consultation; (3) the hatchery actions are subsequently

modified in a manner that causes an effect on the listed species or critical habitat not considered in the consultation; or (4) a new species is listed or critical habitat designated that may be affected by the action.

Among other considerations, NMFS may reevaluate the HGMP if there is information indicating that genetic or ecological impacts, beyond those considered in the consultation, are occurring from the operation of the proposed artificial propagation programs. Additionally, NMFS may seek to reinitiate consultation if the HGMPs are modified based upon information: (1) developed during any subsequent review of the HGMPs that are the basis for these programs; (2) any of the other ongoing hatchery review processes such as the Mitchell Act EIS, the Columbia River Hatchery Scientific Review Group analysis; and (3) other processes such as recovery planning, and *US v. Oregon* negotiations.

12.2.5 Implementation Progress and Status Check-ins

Evaluating a species for potential delisting requires an explicit analysis of population or demographic parameters (the biological criteria) and also of threats under the five ESA listing factors in ESA section 4(a)(1) (listing factors (threats)criteria). Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B). NMFS' Middle Columbia Steelhead Recovery DPS Plan summarizes the biological criteria and threats criteria that will be used to evaluate the DPS for potential delisting.

ESA Requirements for Species Status Reviews
Section 4(c)(2) of the Endangered Species Act requires that NMFS conduct a status review of Middle Columbia steelhead at least once every five years to evaluate the status of the DPS and determine whether it should be removed from the list or changed in status. Guidance for these reviews, developed jointly by NMFS and the U.S. Fish and Wildlife Service in 2006, is on the NMFS website at: http://www.nmfs.noaa.gov/pr/pdfs/laws/guidance_5_year_review.pdf. In addition, ESA section 4(g) requires that once a species has been de-listed that monitoring must be conducted in cooperation with the states for at least five years to ascertain the de-listing action.

The joint NMFS and U.S. Fish and Wildlife Service Guidance identifies the following key components of the status review process:

- a summary and analysis of available information on a given species;
- the tracking of a species' progress toward recovery;
- the recording of a deliberative process used to make a recommendation on whether or not to reclassify a species; and
- a recommendation on whether reclassification of the species is indicated.

The NMFS Northwest Regional Office will coordinate the five-year status review process with scientists from the Northwest Fisheries Science Center. Publication of a Federal Register notice announcing those species under active review is required. This notifies the public that the review is underway and requests information to assist in the review. As recovery plans are completed in the Northwest Region, there is now a need to conduct status reviews in the context of the

biological viability criteria and threats criteria described in the respective recovery plans. Addressing this need and identifying a process and methodology for carrying out the status reviews in the context of recovery planning is a high priority for NMFS.

In 2008, the Northwest Fisheries Science Center carried out a "test" status review for a selected ESU to evaluate how to best carry out the status review and what information is needed to support a robust review and status determination. Based on this preliminary status review exercise and on-going discussions between state, federal, local and tribal monitoring experts, the NMFS Northwest Region is producing a 2009 *Guidance for Monitoring Recovery of Salmon and Steelhead* listed under the ESA. This Guidance will provide recommendations for monitoring that addresses all of the viable salmonid population (VSP) criteria and the listing factors and threats. This draft Guidance is currently being finalized and will be made available to all state, Tribal, local and other entities involved in recovery plan monitoring and adaptive management programs for listed salmon and steelhead species.

NMFS has previously provided three documents describing the need for various kinds of information for determining the status of salmon and steelhead listed under the ESA:

- viable salmonid populations were described in NOAA Technical Memorandum NOAA Fisheries-NWFSC-42 (McElhany et al. 2000);
- additional guidance mainly directed toward habitat restoration monitoring has been given to states and tribes through the Pacific Coastal Salmon Recovery Fund "Performance Goals, Measures, and Reporting Framework (NMFS, December 2006); and
- the initial framework for developing monitoring is described in "Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance" (NMFS, May 2007).

Three types of monitoring are needed to collect the most important information for the status review process. These include: (1) status and trend monitoring, (2) implementation (compliance) monitoring, and (3) effectiveness monitoring. The Middle Columbia steelhead Science Team, in coordination with NMFS, will work with all appropriate parties within the Middle Columbia steelhead DPS to design an appropriate monitoring and evaluation plan to ensure appropriate data is collected to track and evaluate DPS viability status and threats criteria.

NMFS scientists conducting the five-year status review will work closely with the Middle Columbia River steelhead Management Unit coordinators, DPS Science Team, and the Oregon Technical Team formed to provide science input and advice on Middle Columbia River steelhead actions, strategies, research designs, and RM&E priorities to implement the Middle Columbia River Steelhead DPS Recovery Plan. The Recovery Plan Science Team's input will be critical to ensure the most recent monitoring and evaluation data is used during the status review.

For the NMFS Middle Columbia River steelhead status review, the following information will be taken into account, as well as, other relevant information available at the time of the review:

- The biological recovery criteria (ICTRT 2007a) and listing factor (threats) criteria described in the DPS Recovery Plan
- Previous status reviews (including ICTRT 2008)
- The management programs in place to address the threats, including an evaluation of what progress these programs have made on implementing recovery strategies identified in the recovery plan. For example, how many miles of riparian restoration have been carried out relative to specific populations needing viability improvements to meet overall MPG or DPS viability goals?
- Principles presented in the Viable Salmonid Populations paper (McElhany et al. 2000)
- Best available information on population and DPS status and new advances in risk evaluation methodologies
- Other considerations, including: the number and status of extant spawning groups; the status of the major spawning groups; linkages and connectivity among groups; the diversity of life history and phenotypes expressed; and considerations regarding catastrophic risk

The Puget Sound Shared Strategy's Monitoring and Adaptive Management Plan (MAMA) for Chinook salmon provides an example for how to develop effectiveness monitoring metrics. Similar to the MAMA we will use the following questions to assist in tracking progress under major recovery strategies. Effectiveness monitoring metrics are designed to answer the following specific management questions:

- What are the key hypotheses supporting each major strategy in the Recovery Plan?
- What are the expected physical, biological changes and timeframes for those changes?
- What is the overall effectiveness of recovery actions? Is quality habitat being restored faster than it is being lost?
- Are there certain categories of recovery actions that are consistently failing or succeeding?

Effectiveness monitoring is broadly defined to encompass what is often called validation monitoring, and will address effectiveness of key strategies identified in the Middle Columbia River Steelhead Recovery Plan. The RM&E Plan addresses the following key questions:

- To what extent have strategies and actions been implemented and are they effective at meeting their objectives?
- Are recovery actions at the site, watershed *(MaSA, huc6 or other assessment scale as appropriate)* or programmatic scale producing the desired physical and biological changes?
- Are there categories of salmon recovery actions that are consistently more successful than others at meeting their objectives?

Modifying and Updating the Middle Columbia Steelhead Recovery Plan

According to NMFS' Interim Endangered and Threatened Species Recovery Planning Guidance (NMFS Recovery Guidance) (NMFS 2006), immediately following the five-year species review, an approved recovery plan should be reviewed in conjunction with implementation monitoring, to determine whether or not the plan needs to be brought up to date.

NMFS Recovery Guidance provides three types of plan modifications: 1) an update; 2) a revision; or 3) an addendum. An update involves relatively minor changes. An update may identify specific actions that have been initiated since the plan was completed, as well as, changes in species status or background information that do not alter the overall direction of the recovery effort. An update does not suffice if substantive changes are being made in the recovery criteria or if any changes in the recovery strategy, criteria, or actions indicate a shift in the overall direction of recovery; in this case, a revision would be required. Updates can be made by the Salmon Recovery Division which will seek input from the local stakeholder group prior to making any update. An update would not require a public review and comment period.

NMFS expects that updates will result from implementation of the adaptive management program for this plan. Adaptive management depends on the flow of information from the field staff to review managers and planners; hence, it requires frequent updates from monitoring and research on the effectiveness of recovery actions and the status and trends of the listed species. It may be most efficient to keep the recovery plan current by updating it frequently enough to forego the need for major revisions.

A revision is a substantial rewrite and is usually required if major changes are required in the recovery strategy, objectives, criteria, or actions. A revision may also be required if new threats to the species are identified, when research identifies new life history traits or threats that have significant recovery ramifications, or when the current plan is not achieving its objectives. Revisions represent a major change to the recovery plan and must include public review and comment period.

An addendum can be added to a recovery plan after the plan has been approved and can accommodate minor information updates or relatively simple additions, such as implementation strategies or participation plans, by approval of the field office or Regional Administrator. More significant addenda – adding a species to the recovery plan, for example – should undergo public review and comment before being attached to a plan. Addenda are approved on a case by case basis because of the wide range of significance of different types of addenda. NMFS will seek input from stakeholders on minor addenda.

For the Middle Columbia Steelhead Recovery Plan, NMFS will work with each Management Unit lead, the Mid-C Forum and Science Team to identify any changes, amendments or modifications to the Management Unit Plan which will need to be reflected in the DPS Plan. NMFS will coordinate any public notification and review of substantial changes to the Management Unit and DPS Plans with the Management Unit leaders.

State of Oregon Adaptive Management Process

The State of Oregon's Native Fish Conservation Policy identifies elements related to adaptive management that must be included in a state conservation plan. The policy states that a conservation plan will include "a process for modifying corrective strategies based upon the monitoring, evaluation and research results." The policy also identifies that a conservation plan will include "annual and long-term reporting requirements necessary to document data, departures from the plan, and evaluations necessary for adaptive management, in a format available to the public." The elements outlined previously in this chapter are designed to meet the requirements in the NFCP related to adaptive management and the successful implementation of this recovery plan. The State of Oregon will work cooperatively with NOAA to conduct implementation progress and status updates and to report the results of progress and status.

Section 13 Research, Monitoring, and Evaluation

This research, monitoring, and evaluation (RM&E) plan covers the Oregon portion of the Mid-C steelhead DPS. It describes the RM&E recommended for assessing the status and trends in population viability and for evaluating the success of management actions implemented to recover these steelhead populations. In addition, the types of monitoring approaches that are needed, current efforts underway, and additional RM&E needs are presented. Logistical and monetary limitations are understood to exist. However, this comprehensive plan will help to focus efforts towards the common goal of assessing success in population and DPS recovery.

To help identify needed monitoring and evaluation efforts, local managers were queried to identify critical uncertainties which, in their opinion, currently limit our ability to make informed management decisions. Within the context of ESA listing status, monitoring and evaluation should focus on providing measures needed for the critical evaluation of the status and trends of these populations that are informative for their recovery.

This plan is based in part on principles and concepts laid out in the NMFS guidance document, *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance (May 1, 2007)* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf. This plan also borrows from RM&E plans that were developed for Mid-Columbia subbasins and other Columbia Basin regions.

NMFS's guidance document provides a listing status decision framework (Figure 13-1), which is a series of decision-questions that address the status and change in status of a salmonid ESU/DPS, and the risks posed by threats to the ESU/DPS. Consistent with this framework, Oregon's approach focuses on providing key information to determine the condition or status of the populations for each of the four VSP parameters, and the effects of factors (and actions) on the condition or status of the populations.

The plan also follows the principles of adaptive management, the process of adjusting management actions and/or directions based on new information. Adaptive management is considered crucial for salmonid recovery programs because of the length and complexity of the salmonid life cycle, and the uncertainties involved in improving salmonid survival and status. The plan addresses adaptive management by linking monitoring and evaluation to biological and physical responses, and using these results to better design and implement of management actions.

We acknowledge repetition of objectives and methods between MPGs and populations. We expect that in some cases this comprehensive RM&E plan will be separated by MPG and population for use by managers and researches responsible for securing funding and implementing local RM&E efforts. We have developed the plan so that, when separated, the individual MPG plans will be useful as stand alone documents.

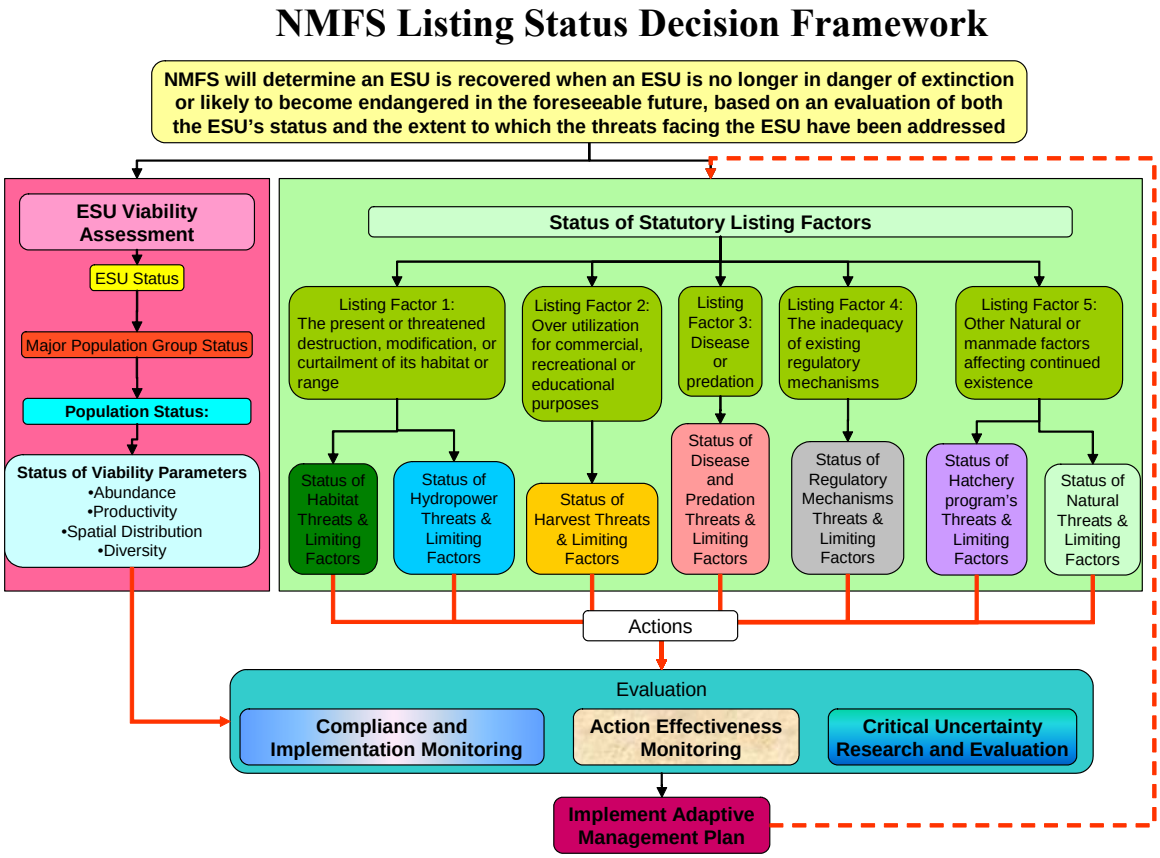


Figure 13-1. NMFS Listing Status Decision Framework.

13.1 Types of Monitoring Efforts

Several types of monitoring are needed to support adaptive management and to allow managers to make sound decisions:

- **Status and Trends Monitoring.** Status monitoring includes measures of the current state or condition of the population at any given time. Trend monitoring tracks these conditions to provide a measure of the increasing, decreasing, or steady state of a status measure through time. Status and trends monitoring includes the collection of standardized basic information used to monitor broad-scale trends over time in the status of fish populations, habitat conditions, and other ecosystem factors affecting fish. This information is the basis for evaluating the cumulative effects of management actions on fish and the aquatic and terrestrial ecosystem.

- **Action Effectiveness Monitoring.** Action effectiveness monitoring involves project-scale monitoring of local conditions to determine if implemented actions were effective in creating the desired proximate change. Action effectiveness monitoring typically is used to determine whether project- or program-specific goals were met. This type of monitoring also includes post-project monitoring to see whether the actions continue to

function as they were designed or intended. Note that status and trend monitoring may be appropriate for fulfilling these needs but that project effectiveness monitoring generally requires focused evaluations of more specific parameters directly associated with actions. Specific indicators and metrics need to be developed in plans for each category of action. Specific plans will include measurable variables or parameters to address each objective, study design (spatial and temporal scale, tests and controls, statistical criteria, etc.), data collection methods and reference examples, and analyses and decisions in response to results.

- **Implementation and Compliance Monitoring.** Implementation and compliance monitoring involves monitoring of management actions to determine if they were implemented as planned and meet established benchmarks. This monitoring is typically conducted by the groups implementing the management and restoration actions.

- **Uncertainties Research.** Uncertainties research includes scientific investigations of critical assumptions and unknowns that constrain effective recovery plan implementation. Uncertainties include unavailable pieces of information required for informed decision making as well as studies to establish or verify cause-and-effect and identification and analysis of limiting factors.

The following sections address each major population group separately. In some cases we provide specific objectives at the population scale to characterize unique monitoring needs. Specific approaches are presented that address each objective. A brief sampling design, including the spatial and temporal scale of application, is provided for each objective. Measurement variables, protocols and a description of the analysis are presented. Ongoing efforts and needed changes and enhancements are discussed for each objective. Existing and potential funding sources are identified and finally, implementation and coordination details are discussed. The techniques described for each population are not necessarily exhaustive, but are meant to be representative of those actions considered to have potential while recognizing logistical and monetary constraints.

13.2 John Day River MPG

Most of the monitoring and evaluation for the John Day River MPG is currently conducted by ODFW. Current status and trends monitoring includes spawner escapement, smolt-to-adult returns (SAR), juvenile abundance, productivity, distribution, and habitat condition. Not all populations are equally monitored but could be assessed with inference through ongoing monitoring of neighboring populations or with expansion of ongoing efforts in the populations that have inadequate monitoring. Limited rigorous effectiveness monitoring occurs and is closely tied to implementation and compliance monitoring of the numerous restoration projects. One of the critical uncertainties for this MPG is hatchery-related threats from out-of-basin hatchery fish that stray into the basin.

The five populations within this MPG (Lower Mainstem, Upper Mainstem, South Fork, Middle Fork, and North Fork) are similar in many respects and are therefore often monitored and evaluated collectively. Further, information collected from M&E efforts within one population

are often applicable to the other four. Where efforts or circumstances differ significantly among populations, differences are noted below within each objective.

Critical Uncertainties

Six critical uncertainties for the John Day River MPG that currently limit the ability to make informed management decisions have been identified by local area managers. We combined these uncertainties with those identified during the recovery planning process to produce the RM&E objectives that are addressed herein by our recommended RM&E efforts. They include:

1. Determine the current status and trend in the abundance and productivity of natural-origin spawners and compare to viability abundance criteria for each John Day population.
2. Determine the status of the spatial structure of each population based on current and historically utilized habitat.
3. Determine the status and trend in conditions of current and historically utilized habitat within each population.
4. Determine the freshwater productivity of each population relative to viability criteria and identify primary habitat factors limiting freshwater production.
5. Determine the current status and change in future status of life history and phenotypic diversity for each population.
6. Determine the effects of disease and predation on the abundance, productivity, diversity and spatial structure of the natural populations.
7. Determine the effects of hydropower on the abundance, productivity, diversity and distribution of the natural populations.
8. Determine the effects of habitat degradation and habitat restoration actions on the abundance, productivity, and spatial structure of the natural populations.

While any of these objectives can be applied to monitoring the recovery of most populations, we will identify details specific to the John Day populations and to the unique circumstances of the five John Day populations in the following recommended approaches. Circumstances and management typically do not differ greatly among the John Day populations, and therefore M&E needs are quite similar across the populations. Some of these objectives (e.g., the out-of-basin influences of hydropower and ocean environment) will remain consistent across all populations in this MPG.

Much of the information needed to monitor the status of John Day River steelhead is currently collected under the ODFW monitoring and evaluation program (Wiley et al. 2005; Wilson et al. 2005b). This plan will describe and supplement the existing programs so that the status and trend of the steelhead populations can be compared with recovery criteria. The following approaches follow those described in the evaluation framework and monitoring guidance set forth in the Adaptive Management for ESA-Listed Salmon and Steelhead Recovery draft document (NOAA 2006) and PNAMP management guidelines.

13.2.1 Lower Mainstem, North Fork, Middle Fork, South Fork, Upper Mainstem John Day Rivers Populations

Objective 1: Determine the current status and trend in the abundance and productivity of natural-origin spawners and compare to viability criteria for each John Day population.

The status of a population is determined by estimating the VSP parameters previously described in this recovery plan. These parameters include adult abundance, population productivity and growth rate, spatial structure, and diversity. The status of these parameters is compared to the population-specific recovery criteria resulting in an overall determination of the status of the population, MPG, and DPS. This is a highest priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- Is the 10-year geometric mean (GM) of naturally-produced steelhead spawners in each John Day River population greater than or equal to the recovery criterion for natural spawners?
- What are the current spawner abundance and five-year trend in abundance?
- What are the current and trend in the 20-year population growth rate?
- What are the current and trend in recruits/spawner compared to the delisting goal?

Performance metrics: Spawner abundance, recruits/spawner.

Approach: Tracking the abundance of adults is an important first step in population monitoring because it integrates the entire life cycle influences on status and trends. No weirs are operated or planned in the John Day River subbasin with the exception of a small temporary weir for research on Bridge Creek in the Lower Mainstem population area. Redd surveys are therefore the only alternative to estimate annual adult abundance for recruits/spawner and trend analyses. The recommended survey design includes a spatially balanced site selection process and a rotating panel design for temporal selection (environmental monitoring and assessment protocol (EMAP) approach; Stevens and Olsen 2004). ODFW currently uses this approach to estimate annual spawner escapement to the entire John Day River subbasin. Redds are counted bi-weekly on 2-km reaches selected by using a four-year rotating panel design with 50 randomly selected reaches sampled per year in the John Day River MPG. Ideally, sampling using this design would also be conducted at the population scale which would require additional samples to achieve greater accuracy and precision. In addition, index areas specific to the population that were established in 1966 are sampled annually by ODFW managers. These index data were originally used to estimate viability criteria and continue to provide valuable long-term trend information. A census redd count of a representative population outside of the basin is also conducted to establish a fish/redd ratio. Redd count surveys are currently conducted by walking and/or floating all streams within the index (one-time annual counts) and randomly selected reaches (bi-weekly counts, ≥ 3 counts/year). A fish/redd ratio is estimated by counting spawners passed above a weir (outside of the John Day River subbasin) and subsequent spawning ground redd

surveys, of similar design to those conducted in the John Day, of all known utilized habitat above the counting weir.

Analysis: Estimate the number of naturally produced spawners using proportions of observed naturally produced fish (unmarked) and hatchery (fin clipped) fish, total number of redds, expansion factor of surveyed stream length/available stream length, and fish/redd ratio. Calculate 10-year GM for abundance of naturally produced fish. Calculate recruits/spawner based on redd counts and estimated spawner age structure. Analyze as a time series (trend analysis).

Status: BPA currently funds the sampling of randomly selected reaches for spawning surveys at the MPG scale. LSRCP and NOAA currently fund spawner and redd counts (for fish/redd ratio) on a reference stream in the Grande Ronde River basin. State of Oregon funds index spawning ground surveys. Field work is currently implemented and coordinated primarily by the ODFW and ISEMP. Population-level sampling has been conducted for the South Fork population during 2006 and 2007 and may be rotated annually to other populations. However, additional funding would be required to conduct population-level sampling for the larger populations (Lower Mainstem, North Fork) within the MPG. Population-scale monitoring for the Middle Fork population will be initiated in 2008 as part of the intensively monitored watershed (IMW) approach. This IMW work is funded by NOAA through OWEB. Much of the Upper Mainstem population is within private property where access is limited, and therefore population-scale spawner surveys are logistically very difficult there. Similarly, private property dominates the Lower Mainstem population area and the low density stream network coupled with remote access for several major tributaries and more frequent turbid water further complicates sampling and logistics of redd surveys.

Objective 2: Determine the status of the spatial structure of each population based on current and historically utilized habitat.

This is a highest priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:
- What is the spatial distribution of spawning within each population?
- What is the current spatial extent and distribution of rearing habitat used by juvenile steelhead within each population?

Approach: The same EMAP of all known spawning and rearing areas as used for determining abundance of spawners is recommended and currently implemented by ODFW for refining the known spatial extent of both adult and juvenile steelhead in the John Day MPG. Fifty sites within the John Day MPG are sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. All observed adult spawners and redds are geographically referenced using handheld GPS units for inclusion in a GIS. Juvenile steelhead are sampled using snorkeling or electrofishing techniques. This approach is refining current knowledge of steelhead spatial

distribution throughout the John Day River subbasin. Current sampling efforts in the South Fork population are adequate and the future sampling associated with the Middle Fork IMW will provide information needed for this population. Expanded sampling in the Lower Mainstem, North Fork, and Upper Mainstem populations will be required to get adequate population specific information.

Analysis: Data are currently analyzed as distribution data in a GIS format. The known distribution of steelhead is modified when previously unknown blockages to migration are discovered. Juvenile steelhead are evaluated as fish/pool in each study reach.

Status: BPA currently funds the sampling of randomly selected reaches for spawning surveys. BPA has eliminated funding for juvenile distribution work after 2007. Additional funding may be procured from OWEB. Field work is currently implemented and coordinated primarily by the ODFW and ISEMP. ISEMP is developing contracts with ODFW to reinstate habitat and juvenile distribution monitoring that will address sampling at population spatial scales. Additional work on juvenile fish is conducted by the USFS PACFISH Biological Opinion project on federally owned lands and by CTWSRO on tribal managed properties. The same limitations indicated above in Objective 1 are relevant here as well.

Objective 3: Determine the status and trend in conditions of current and historically utilized habitat within each population.

This is a highest priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- What is the status and trend in habitat quantity and quality throughout the John Day MPG area?
- What is the status and trend in habitat quantity and quality for each of the populations in the John Day MPG?

Approach: The same EMAP of all known spawning and rearing areas as used for determining abundance of spawners is recommended for sampling the known spatial extent and status and trend of steelhead habitat in the John Day MPG. Fifty sites within the John Day MPG are sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. Habitat variables follow ODFW Aquatic Inventories design (Moore et al. 2002) and are measured at the unit and reach scale.

Analysis: Data are currently analyzed as distribution data in a GIS format. Sample sites can be associated to specific populations but sample draw was conducted to represent MPG level. Database and GIS formatting of data allow associations with land use, land vegetation coverage, and many other attributes at watershed and population scales. The survey effort needs to be expanded to provide monitoring at the population level. Current and future planned efforts are adequate for the South Fork and Middle Fork populations but not the other three.

Status: BPA has eliminated funding for basin-wide habitat work after 2007. Work is currently unfunded for most populations. Habitat monitoring will continue for Middle Fork population using NOAA/OWEB funding as part of the Middle Fork IMW. ISEMP is developing contracts with ODFW to reinstate habitat and juvenile distribution monitoring that will address sampling at population spatial scales.

Objective 4: Determine the freshwater productivity of each population relative to viability criteria and identify primary habitat factors limiting freshwater production.

This is a highest priority objective.

Type of monitoring effort: Long term status and trend monitoring for productivity and uncertainties research for limiting factors.

Monitoring questions:
- What are the current and trend in freshwater productivity measured as smolts/redd?
- What are the primary habitat factors limiting freshwater production of steelhead?

Approach: The ratio of smolts/adult is one recommended measure of freshwater productivity. Smolts are typically counted using traps as they migrate out of their natal habitat. If weirs are not present to count adults, then redd counts can act as a surrogate measure. Freshwater productivity is measured as smolts/redd or smolts/adult. Trapping with rotary screw traps (RSTs) and mark-recapture are currently used to estimate smolt abundance for significant portions of three populations (South Fork, Middle Fork, Upper Mainstem) in the John Day MPG. Similar efforts have been attempted for the North Fork population with limited success due to physical constraints. The structure of the watershed for the Lower Mainstem population precludes effective sampling of smolts with traps because the tributaries are disperse and enter the Mainstem where it has very large discharge during seasonal flow events. Redd counts are estimated using the previously mentioned approach and an EMAP sampling framework. Sample draws for redd surveys need to be directed at the population segments above smolt trapping locations. Actual freshwater productivity estimates are derived estimates not direct measures. For example, egg-to-smolt survival requires an estimate of the number of eggs deposited by individual females or deposited in each redd. Parr-to-smolt survival can be estimated by capturing a representative number of parr in their rearing habitat, PIT tagging them, and then monitoring their recapture at the downstream smolt traps. Migration survival can similarly be estimated by monitoring detections of PIT-tagged individuals as they pass through PIT tag detection facilities.

Identification of factors limiting freshwater production by RM&E efforts provides much needed direction for restoration efforts and is best explored using an uncertainties research approach. Several physical and biological factors can potentially limit production. Therefore, a multivariate or hierarchical approach may be appropriate for identifying factors. For example, data from habitat surveys can be combined with data from long-term monitoring of discharge and temperature and fish growth and distribution information to identify factors potentially limiting productivity. Often, simple presence/absence

information of parr or adults can be examined in the context of existing habitat information and used to initially deduce and explore more complex predictive relationships.

Analysis: Smolt abundance is estimated using RSTs and mark/recapture techniques (Thedinga 1994, Steinhorst 2004). Survival and productivity measures are calculated ratios of abundance from one life stage to another.

Status: BPA currently funds trapping of smolts and spawning surveys for redd counts. NOAA and OWEB will fund future work for identifying limiting factors under the IMW approach for the Middle Fork John Day River. With current efforts there will be estimates for the South Fork and Middle Fork populations. Efforts will have to be expanded to collect information for the other populations. Similar efforts, funded by NOAA and BPA, to estimate freshwater productivity are planned for an IMW on Bridge Creek, a tributary of the Lower John Day River. Smolts-redd estimate are not logistically feasible for the Lower Mainstem and North Fork populations. Outflowing waters are too large for efficient trapping of smolts using RSTs and commingling of smolts from other populations would introduce additional complications for unique identification. It may be feasible to monitor a representative portion of the North Fork population (above Desolation Creek, for example) if additional funds become available.

Objective 5: Determine the current status and change in future status of life history and phenotypic diversity for each population.

This is a high priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- What proportion of steelhead spawners in the John Day MPG are out-of-basin hatchery strays?
- What is the origin of out-of-basin strays?
- What is the population-level genetic composition of the John Day MPG and of individual populations?

Approach: The John Day River basin lacks facilities to capture adult steelhead. Determination of out-of-basin strays will therefore rely on identification of hatchery-marked adults observed on spawning ground surveys, in creel surveys, from incidental catches, and from detections of PIT tags at PIT tag antenna arrays. See also Objective 6 for harvest monitoring.

To determine population-level genetic composition for the MPG, genetic data that allow an objective determination of population structure are required. Age-0 *O. mykiss* from four representative streams in each population segment have been sampled for three consecutive years beginning in 2005. A minimum of three cohorts were sampled using non-lethal fin tissue for DNA analysis. Populations will be characterized using a suite of nuclear DNA markers, including both microsatellite loci (variable-number simple-sequence repeats) and

non-coding single nucleotide polymorphisms (SNPs), or base substitutions assayed via restriction enzyme analysis (Moran et al. 1997).

An EMAP of all known spawning areas is currently employed in the entire John Day River MPG. Fifty sites within the John Day MPG are sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. ODFW managers also continue to annually visit pre-determined and long-standing index sites for spawners. These index surveys continue a long-term trend dataset that was initiated in the 1960's. The number of marked (adipose fin clip) and unmarked (presumably natural-origin) fish are visually identified on all spawner surveys. All observed carcasses marked with a fin clip are sampled for coded-wire tags to determine the presence of a coded-wire tag and hatchery origin. Expanded sampling efforts are recommended to provide population specific hatchery fraction information.

Because there are no permanent weirs in the John Day River basin, the operation of semi-permanent PIT tag antenna arrays is critical for the identification of the origin of hatchery strays. PIT tag monitoring should be accomplished near the downstream extent of watersheds, near RSTs, to monitor the passage of tagged adults. These antennas can serve a dual purpose by also aiding in the determination of the capture efficiency of RSTs.

Analysis: Estimating the proportion of out-of-basin strays is a simple comparison of the number of marked and unmarked spawners and carcasses observed. Direct comparisons can then be made with recovery criteria. DNA tissue samples are analyzed by NMFS using known microsatellite markers. Microsatellite loci are analyzed using pairwise FST comparisons to estimate levels of gene flow and to identify geographic areas that contain genetically differentiated populations. Genetics monitoring is conducted under the NMFS Columbia Basin-wide steelhead genetics monitoring program.

Status: Spawning ground surveys are implemented and coordinated primarily by the ODFW with input from ISEMP participants. BPA currently funds spawning ground surveys for EMAP reaches and state funds are used for index surveys. Genetic analysis is implemented and coordinated collaboratively between ODFW and NMFS Northwest Science Center. Federal funds are used for genetic stock analysis.

There are currently no creel surveys conducted in the John Day River subbasin. Current evidence suggests that out-of-basin hatchery strays is a particular problem for the Lower Mainstem population. There appears to be a negative correlation between distance from the mouth of the John Day River and presence of hatchery strays. The scope of surveys is currently inadequate to make population specific estimates of the proportion of spawners that are hatchery origin.

As of 2009, semi-permanent antenna arrays are operated at McDonald Ford on the Lower John Day River, on the South Fork John Day River, Middle Fork John Day, and on Bridge Creek. The latter three are operated as part of the ongoing IMW studies by ISEMP and ODFW. The McDonald Ford array is operated by Biomark, Inc. in cooperation with NOAA and ODFW.

Objective 6: Determine the effects of disease and predation on the abundance, productivity, diversity and distribution of the populations.

This is a moderate priority objective.

Type of monitoring effort: Status and trend monitoring.

Monitoring questions:

- What is the prevalence of whirling disease in the John Day River basin and what is its influence on the natural steelhead populations?
- What is the predation rate and predatory impact of introduced fishes in the John Day River on juvenile steelhead?
- What is the effect of predation from piscine predators in the Columbia River migration corridor on juvenile steelhead originating from the John Day River?
- What is the effect of predation from avian predators in the Columbia River migration corridor on juvenile steelhead originating from the John Day River?

Approach: The current distribution and influence of whirling disease on wild steelhead populations is not fully understood. Representative sentinel stations should be established and monitored through time for each population to measure prevalence and intensity of infection rates of the disease. Infection, or the presence of *Myxobolus cerebralis* DNA, is detected by polymerase chain reaction (PCR) analysis. A logical place to locate initial sentinel tests would be in locations where hatchery strays are known to be prevalent because they are a known vector of transmission from infected watersheds in northeast Oregon (Sollid et al. 2004). Sentinel stations should then be placed near the mouths of important tributary and mainstem habitats occupied by fry and parr life history stages of steelhead. While all populations in the John Day have some susceptibility to disease, the prevalence of hatchery strays and habitat conditions in the Lower Mainstem population area likely make this population more vulnerable than those upstream. The initial focus of study should be in the Lower Mainstem population.

ODFW currently conducts annual collections of smallmouth bass *Micropterus dolomieui* in the John Day River using angling techniques. Collected stomach samples are analyzed for the presence of juvenile salmonids. These data could be incorporated into a bioenergetics model to derive a population-level consumption estimate imposed by introduced fishes. Sampling of predatory fish diets should occur during times and locations when and where their distribution overlaps with juvenile steelhead. Interpretation of the predatory impact in the migration corridor should be conducted from methods established in published literature (Ward et al. 1995, Fritts and Pearsons 2006).

To evaluate avian predation, colonies are monitored for presence of PIT tags originating from specific populations (Collis et al. 2001). Bioenergetics models are used to expand tag recoveries at colonies to population-level impacts (Antolos et al. 2005). We acknowledge that both the Columbia River mainstem piscine predator and avian predator monitoring needs are outside the scope of this plan. However, we encourage adequate monitoring of these limiting factors and threats.

ODFW currently PIT tags 4,000 juvenile steelhead migrants each year in the John Day River basin for estimation of SAR. Determining the fate of PIT tags in this database should be utilized for examining the influences of migration corridor predation.

Analysis: The proportion of SAR attributable to predatory mortality could be estimated from the predation bioenergetics modeling results. Infection rates of sentinel fish from disease would provide some indication of the potential impacts of whirling disease.

Status: ODFW currently tests opportunistically for the presence of diseases in juvenile salmonids submitted as mortalities from rotary screw traps and other sampling operations from the John Day River basin. PIT tagging of juvenile steelhead is currently completed by the ODFW with funding from the BPA. The whirling disease foundation, whirling disease initiative, and Oregon Sea Grant are potential funding sources for whirling disease investigations. Investigations of predation in the migration corridor have been conducted by many agencies with various funding sources including BPA and USACE. We encourage the continuation of the piscine and avian predation monitoring.

Objective 7: Determine the effects of hydropower on the abundance, productivity, diversity and distribution of the natural populations.

This is a high priority objective.

Type of monitoring effort: Long term status and trends.

Monitoring questions:

- What is the effect of Columbia River hydropower operations on juvenile steelhead outmigrating from the John Day River populations?
- What is the effect of Columbia River hydropower operation on returning adult steelhead originating from the John Day River populations?

Approach: PIT tags have been used successfully to measure the influence of hydropower operations on migrating salmonids (Berggren et al. 2006, Schaller et al. 2007). ODFW has cooperated with the CSS study by PIT tagging steelhead smolts as they migrate out of the John Day River Basin. These PIT-tagged fish are subsequently monitored for detections at FCRPS facilities along the migration corridor at both juvenile and adult life stages using Data Access in Real Time (DART) and PIT Tag Information System (PTAGIS) databases. Detection probabilities of juvenile salmonids migrating downstream at FCRPS facilities are modeled using the Survival Under Proportional Hazards (SURPH) analytical tool (Lady et al. 2003). Adult detection (purportedly 100%) is currently available at ladders on several dams, including Bonneville and McNary, and is expected in the near future at The Dalles and John Day dams.

Analysis: Juvenile survivals at each FCRPS facility can be estimated using the SURPH model. Adult survival between facilities will soon be possible by comparing detections at adult ladder facilities along the migration corridor. Rates can be expanded to population-level impacts using the relative number of fish PIT tagged and smolt abundance estimates

generated from mark-recapture at RSTs. Adult detections within the John Day River basin, subsequent to those in the Mainstem Columbia River, will be used to determine the relative proportion of successful migrants from each migration strategy outside of the basin.

Status: ODFW currently PIT tags emigrating smolts and monitors their detections at mainstem hydropower facilities. Coordination with comparative survival studies (CSS) occurs with the Fish Passage Center. Currently, juvenile steelhead are PIT tagged representing three populations (South Fork, Upper Mainstem, and Middle Fork) in the John Day. Estimates derived for these populations would be representative for the remaining John Day populations. NMFS and Biomark operate a developmental PIT tag antenna array on the Lower John Day River. This array will allow partial detection of PIT-tagged fish migrating through the lower John Day River.

Objective 8: Determine the effects of habitat degradation and habitat restoration actions on the abundance, productivity, and spatial structure of the natural populations.

This is a high priority objective.

Type of monitoring effort: Status and trend monitoring; implementation and compliance monitoring; effectiveness monitoring.

Monitoring questions:

- Status & Trend Monitoring—What is the current status and trend of steelhead habitat?
- Implementation and Compliance Monitoring—Has the management action been implemented in the prescribed manner and achieved its objectives?
- Effectiveness Monitoring—Have the management actions significantly influenced the viability of John Day River steelhead populations?

Approach: Status and trend monitoring at the subbasin and population scale is best conducted by using a spatially explicit sampling approach such as the EMAP approach developed by the EPA. Measured habitat variables vary depending on the specific question addressed but are directed at those closely related to salmonid requirements, targeted for restoration, or identified as limiting recovery. Remote sensing (e.g. thermal infrared (TIR) imagery; light detecting and ranging, (LIDAR); and spatially referenced color imagery) is also appropriate and typically addresses spatial scales at watershed or larger landscapes. We typically use ODFW aquatic inventories which include riparian, within channel and physical properties.

Compliance monitoring of restoration projects incorporates record keeping and reporting of activities. Compliance monitoring should be primarily conducted by the implementing party and should include any parameters indicated in related work statements. Although some compliance monitoring is currently underway, there is need to expand at the project scale and for aggregation to assess at the population scale.

Effectiveness monitoring can be approached at the watershed and project spatial scales. IMWs are currently used in some places for the watershed scale. Effectiveness monitoring should preferably be directed at measures of abundance, survival, growth, etc. of steelhead or

abiotic or biotic factors limiting their recovery. A modified before-after-control-influence (BACI) design (including spatial replication) is recommended for measuring the effectiveness of active restoration activities (Jones & Tonn 2004). For passive restoration activities, a BACI design that monitors trends through time may be appropriate. If comparisons are made to reference or control sites, they should be under similar environmental conditions experienced by the treatment site but outside the influence of treatment activities. Restoration action implementing entities must coordinate with monitoring groups prior to scheduled activities—preferably years in advance to allow measurement of pre-treatment variables. Temporal scales must account for delays due to life history and life cycle timeframes.

Analysis: Direct comparisons of measured parameters with recovery criteria can be made. Otherwise, measures at smaller scales will need to be scaled up to determine if they would have desired responses at the population level.

Status: Implementation monitoring is currently conducted by the groups that implement the activities (e.g. ODFW, CTUIR, CTWSRO, watershed councils, etc.). ODFW currently conducts limited effectiveness monitoring of selected restoration projects within the John Day River basin. IMWs were established in the Middle Fork John Day River and Bridge Creek on the Lower John Day River in 2007. Remote sensing is typically conducted by professional consultants. Funding from BPA, OWEB, NOAA, and other sources has supported past and current activities. There is limited implementation monitoring underway and a significant need to compile information across projects for assessment at the population scale.

13.3 Umatilla/Walla Walla Rivers MPG

Steelhead restoration activities in the Umatilla subbasin include supplementation of the endemic steelhead population, harvest management, and habitat, flow, and passage improvement projects. The "Comprehensive Research, Monitoring, and Evaluation Plan for Umatilla Subbasin Summer Steelhead and Chinook Salmon" (Umatilla RM&E plan; CTUIR and ODFW 2006) is a detailed plan for obtaining information needed to assess the performance and evaluate the effectiveness of these habitat restoration, harvest management, and hatchery programs. The RM&E aspects of this plan are designed to assess the current efforts and test new strategies for the supplementation and restoration of steelhead and the establishment and enhancement of commercial and recreational fisheries. Due to the lack of pre-treatment data, managers rely primarily on status and trend data and comparison to out-of-subbasin reference populations to assess the success or failure of management strategies and to make adaptive management decisions.

Most of the monitoring and evaluation for the Umatilla/Walla Walla Rivers MPG is currently conducted by ODFW and CTUIR. Status monitoring is performed for all projects in the Umatilla subbasin, including natural production, hatchery evaluation, and juvenile outmigration and survival. Proposed natural production status monitoring includes abundance indices for juveniles (parr and smolts), adult abundance, recruits per spawner, estimated redd numbers, life history characteristics, as well as flow, temperature, and habitat data to assess the success of flow augmentation and stream restoration work. Hatchery evaluations include the monitoring of

smolt-to-adult returns, smolt-to-adult survival, catch contribution, catch distribution, and straying rates. Juvenile outmigration monitoring (which was discontinued in 2007 due to BPA budget cuts, then re-started in 2009) includes abundance of outmigrating smolts, travel timing, and survival rates to downstream dams. In addition, the fishery is monitored using creel surveys and marine fishery observations to estimate the contribution of Umatilla River fish to the commercial and recreational fisheries. RM&E for the two Oregon populations within this MPG are addressed separately below.

13.3.1 Umatilla River Population

Critical Uncertainties
Seven critical uncertainties for the Umatilla River population that currently limit the ability to make informed management decisions have been identified by local area managers.

1. What are the status and trends of steelhead and their habitat in the Umatilla basin?
2. What are appropriate and effective rearing and release strategies for summer steelhead reared at Umatilla Fish Hatchery?
3. Will the historical summer steelhead fishery be sustained by hatchery releases of summer steelhead?
4. To what extent will hatchery summer steelhead released in the Umatilla contribute to out-of-subbasin fisheries?
5. To what extent will supplementation alter the genetic diversity and life history characteristics of the native steelhead population?
6. To what extent will supplementation enhance natural production of summer steelhead?
7. How will habitat protection and enhancement actions influence abundance, productivity, life history diversity, and long-term sustainability of Umatilla steelhead?

We used these uncertainties and others identified during the recovery planning process to produce the monitoring and evaluation objectives and the recommended M&E efforts. We list the priority level of each objective from highest to low, with a monitoring and evaluation focus on the highest priority activities. This does not mean that criteria ranked as moderate or low are not important to monitor. Rather, it means that limited resources will be applied to monitoring those aspects of recovery that are most important. Monitoring of moderate and low priority criteria will occur as resources are available. This plan does offer possible metrics and methods for monitoring medium and low priority criteria. Monitoring objectives listed as highest or high priority address population and environmental status, natural production, the hatchery program, flow, passage, and other habitat actions and fisheries.

We combined the aforementioned uncertainties with those identified during the recovery planning process to produce the RM&E objectives that are addressed herein by our recommended efforts. Not all objectives are associated with each population segment. The objectives include:

1. Monitor and assess the status and trends of abundance and productivity of natural- and hatchery-origin adult steelhead.

2. Determine the status of the spatial structure of the population based on current and historically utilized habitat.
3. Monitor and assess the abundance, timing, life history characteristics, and in-stream survival of out-migrating steelhead.
4. Determine the current status and change in status of life history and genotypic diversity in the population.
5. Identify and assess factors limiting viability of Umatilla River steelhead.
6. Determine the status and trend of current and historically utilized steelhead habitat in the Umatilla subbasin.
7. Determine the influence of the current hatchery supplementation program on the natural population.
8. Monitor and assess the impact of flow enhancement on steelhead survival, habitat, and migration.
9. Determine the effect of mainstem hydropower operations and operational improvements on viability of Umatilla River steelhead population.
10. Determine the effect of harvest on the abundance, productivity, diversity, and distribution of the natural population.
11. Determine the effect of predation on the abundance, productivity, diversity, and distribution of the natural population.
12. Monitor production, survival, harvest and spawning of hatchery-origin steelhead.
13. Determine the transmission and effect of disease on the abundance, productivity, diversity and distribution of the natural population.

Some of the information needed to monitor the status of Umatilla summer steelhead is currently collected under the ODFW and CTUIR monitoring and evaluation program as described in the Umatilla RM&E plan, while limited monitoring activities that address the effectiveness of irrigation screening are also conducted by the Bureau of Reclamation. The research, monitoring, and evaluation objectives and approaches that follow are primarily from the Umatilla RM&E plan (CTUIR and ODFW 2006). Some of these objectives have been supplemented so that the status and trend of the steelhead population can be compared with recovery criteria. More detailed information on approaches and analysis is contained in the Umatilla RM&E plan.

Objective 1: Monitor and assess the status and trends of abundance and productivity of natural- and hatchery-origin adult steelhead.

Adult returns to Three Mile Falls Dam (TMFD) are critical for monitoring the status and long-term trends of steelhead in the Umatilla subbasin (Critical Uncertainty No. 1). Monitoring trends in productivity metrics will be critical to assessing the performance of the Umatilla subbasin fish restoration program. These measures will also be used in stock-recruitment models to estimate natural production capacity of the subbasin. This is considered a highest priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What are the annual abundance and time-series trends in abundance?

- Is the 10-year GM of naturally-produced steelhead spawners in the Umatilla subbasin greater than or equal to the recovery criterion for natural spawners?
- What are the current and trend in the 20-year population growth rate?
- What are the current and trend in smolts/spawner?
- What are the current and trend in adult recruits per spawner?

Performance metrics: Number of natural- and hatchery-origin adult returns to the Umatilla River, run timing of natural- and hatchery-origin adult returns, smolts-per-spawner, adult recruits per spawner.

Approach: Numbers of adult natural- and hatchery-origin returns are currently enumerated by trap counts and video monitoring at the TMFD (RM 3.7) fish ladder. A complete count of escapement past TMFD is obtained, as all returning adults must use this fish ladder. During trapping, fish are routed into a sorting complex. During sorting, data, disposition, and number trapped by sex, age class (classified by fork length), and marks are collected. Fish are also examined for presence of coded-wire tags. Additional age, length, and CWT information is obtained when broodstock collected at TMFD are spawned and from snouts collected in the Umatilla River fishery. The natural origin of unmarked steelhead is cross-checked by examining scale patterns on all unmarked fish collected for broodstock or sampled in fisheries and on the spawning grounds. Harvest is monitored below TMFD to obtain an estimate of returns to the mouth of the Umatilla River. A roving creel survey is used to count and contact anglers in the steelhead fishery. During video enumeration, total counts of steelhead are obtained from review of the video tapes. During the video review, about 50% of steelhead can be classified as hatchery or natural by the presence or absence of an adipose fin, respectively. Origin of the unidentified steelhead, and age, sex, and mark composition of video monitored steelhead are estimated as their mean percent composition from trapping periods immediately before and after the video period.

Analysis: Counts of adult returns to TMFD plus estimated harvest below TMFD are combined to estimate the number of natural- and hatchery-origin fish that return to the mouth of the Umatilla River. Counts of adults in combination with other measures are used to estimate key metrics of survival (smolt-to-adult survival, pre-spawn mortality) and productivity (smolts-per-spawner, adult recruits-per-spawner ratios). In-basin freshwater productivity has been estimated as the number of smolts-per-spawner from spawner abundance estimates and smolt abundance estimates collected by the BPA-funded Umatilla Smolt Outmigration and Survival Project. Adult-to-adult productivity is measured as recruits-per-spawner ratios using spawner abundance data and estimates of total adult spawner production resulting from each brood year.

Status: Adult and smolt estimates are currently funded. BPA currently funds counts at TMFD, creel surveys, and harvest estimates. Returns have been enumerated at TMFD using an electronic fish counter from 1966-1983 and mark-recapture methods from 1983-1987, after which a trapping and collection facility was constructed. All returning adults were trapped until the 1999 return year, after which alternating trapping-video enumeration was implemented. Funding for smolt abundance was discontinued in 2007, then re-started in 2009.

Objective 2: Determine the status of the spatial structure of the population based on current and historically utilized habitat.

Spawners can escape differentially to each watershed due to habitat conditions, pre-spawn mortality, and stochasticity. The production of juveniles can vary among watersheds due to spawner abundance, spawner productivity, habitat quality, habitat quantity, egg mortality, fry mortality, or parr mortality. An understanding of spatial and temporal variance in both spawner and juvenile distribution is therefore necessary to address several of the critical uncertainties. This is a highest priority objective.

Type of monitoring effort: Long-term status and trends monitoring.

Monitoring questions:

- What is the spatial arrangement of the occupied spawning areas within the population boundaries?
- What is the distribution and density of spawners on the spawning grounds?
- What is the current spatial extent and distribution of rearing habitat used by juvenile steelhead?
- What is the distribution of juveniles on the rearing grounds?

Performance metrics: Spawner distribution, redd distribution, spawn timing, rearing distribution, juvenile density and distribution.

Approach: Sampling will be conducted throughout all known spawning and rearing habitat. Sample site selection design will follow an EMAP protocol (Stevens and Olsen 2003, 2004; www.epa.gov/emap). Redds are enumerated using multiple-pass visual surveys of the selected sample reaches. The location of each redd will be georeferenced. Although few carcasses are recovered, carcasses will be measured and weighed, and a scale sample will be collected for age, growth and origin analysis.

Enumeration of juvenile out-migrants on Meacham Creek, a major tributary to the Umatilla River, started with a mark-recapture project in 2009. Habitat restoration conducted under CTUIR's Meacham Creek Habitat Enhancement Project will be evaluated for effectiveness using smolt production ratios as performance measures. It is hypothesized that Meacham Creek smolt production will make up a larger proportion of the Umatilla Basin's total smolt production as habitat restoration efforts come to fruition.

Juvenile survey reaches will be randomly selected within watersheds using the same EMAP protocol. Sampling will be stratified by increasing intensity in watersheds that are receiving supplementation, flow, or habitat treatments. At least thirty juvenile sites will be surveyed annually. This sample size approaches the practical maximum for field efforts, surpasses the sample size required to detect geographic patterns in community structure related to and independent of habitat variability, far exceeds the sample size needed to detect habitat changes in each watershed (Roper et al. 2003), and should be sufficient to detect a 20-50% change in salmonid densities per annum at the watershed scale.

Analysis: Annual estimates of density will be produced for each life-history stage and watershed. A geostatistical analysis will be conducted using population and habitat data to estimate fish-habitat relationships and to produce a geostatistical stock assessment of spawners and juveniles. Associative, trend, and descriptive analyses will be used to monitor changes in spawner and juvenile populations across space and time. Detailed analysis to be conducted is located in the detailed methods section of the Umatilla RM&E Plan.

Status: Spawner abundance data are collected by the Umatilla Natural Production Project. Spawner monitoring is funded by BPA and is ongoing. Trapping to enumerate juvenile out-migrants on Meacham Creek began in 2009. Summer steelhead index sites have been surveyed in the Umatilla for more than 10 years.

Objective 3: Monitor and assess the abundance, timing, life history characteristics, and in-stream survival of out-migrating steelhead.

An estimate of smolt abundance for natural-origin steelhead in the lower Umatilla River is essential to answering critical uncertainties related to natural production capacity and within subbasin productivity. In addition, an understanding of migration success and survival is necessary to identify in and out-of-subbasin limiting factors (including environmental conditions, flow, fish habitat, hatchery rearing and release strategies, predation, and passage difficulties) and estimated loss by life stage for natural- and hatchery-origin steelhead. This objective addresses Critical Uncertainties numbers six and seven. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What are the abundance, timing, and in-stream survival of out-migrating steelhead?
- What are the life history characteristics of out-migrating steelhead?

Performance metrics: Migration parameters, abundance, survival, and life history characteristics (including age, size and condition) of emigrating smolts.

Approach: Smolt abundance will be estimated for naturally-reared steelhead emigrating from Meacham Creek to TMFD, and for smolts from the lower Umatilla River, using fish collection and trapping efficiency on lower Meacham Creek and at TMFD. Smolt survival and migration parameters (timing, duration and travel speed) will be monitored for naturally- and hatchery-reared species using PIT tags and remote interrogation at Three Mile Falls and lower Columbia River dams. Juvenile life history characteristics including smolt outmigration timing, length, age, condition and smolt status will be collected.

An incline plane trap set in West Extension Canal is currently utilized to capture emigrating juvenile salmonids in the lower Umatilla River. The trap is located within the juvenile bypass facility off TMFD. Trapping is conducted between February and June, and coincides with the primary smolt emigration period. Fish are enumerated by species, race and origin (natural or hatchery). Scales are collected on a subsample of natural summer steelhead for age analysis and developmental (smoltification) stage for all species is assessed by visible

brightness and the presence or absence of parr marks. All smolts captured during fish sampling are interrogated for PIT tags. To improve total outmigration estimates, CTUIR's Natural Production Monitoring and Evaluation Project will enhance PIT tag detection rates at TMFD by installing improved detectors on the smolt bypass structure on the west side of the dam and in the adult fish ladder on the east side of the dam.

Analysis: Smolt survival estimates have previously been calculated using the Migrant Abundance Method (Burham et al. 1987 and Dauble et al. 1993) and the SURPH 2 model (http://www.cbr.washington.edu/). Environmental variables including water discharge, flow, temperature and water clarity in the lower river will be monitored and relationship to smolt survival and/or migration success will be assessed using regression and correlation analyses. Associative and trend analyses will be used to evaluate outmigration.

Status: Smolt abundance estimates for the Umatilla River basin were provided by the BPA-funded Umatilla Smolt Outmigration and Survival Project until 2007, when funding was discontinued. Funding was re-established for that project in 2009. Funding was obtained by CTUIR from BPA to estimate Meacham Creek smolt abundance and survival beginning in 2009.

Objective 4: Determine the current status and change in status of life history and genotypic diversity in the population.

Natural steelhead production in the Umatilla River basin is supplemented by hatchery-raised fish that spawn in natural environments. However, the artificial propagation of fish and manipulation of breeding structures includes genetic risks that may compromise the goal of supplementation (Currens and Schreck 1995). It is important to monitor the genetic characteristics of natural and hatchery-produced fish to insure that the artificially produced fish resemble the wild population genetically, that adequate effective population sizes are maintained to prevent catastrophic genetic drift, and that outbreeding depression does not reduce the reproductive success of the entire population. This objective addresses Critical Uncertainties numbers five and six. This is a high priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- What proportion of steelhead spawners are out-of-basin hatchery strays?
- What is the origin of out-of-basin strays?
- What are the population-level genetic characteristics of the Umatilla River steelhead population?
- What is the status of life history patterns and variation in the Umatilla steelhead population?

Approach: Numerous life history metrics are monitored in the natural- and hatchery-origin steelhead populations: adult and juvenile migration timing, growth rates, age structure, sex ratios and size at age. A subsample of natural-origin juveniles is PIT-tagged on the spawning

grounds for outmigrant detection at TMFD and Columbia Mainstem facilities. Scales of natural-origin juveniles can be sampled during EMAP surveys and lower river trapping.

We will collect genetic samples from 100 returning adults of both natural- and hatchery-origin collected at TMFD. In addition, juvenile samples have been collected for three years (2005-2007) from multiple locations in the basin. Genetic samples will consist of fin clips, which will be immediately preserved in alcohol. Sampling will be initially conducted for five years to determine changes in the performance metrics over a generation and assess the periodicity of additional sampling.

Analysis: Migration timing and age structure are assessed by distribution comparisons. Age and growth analysis will be conducted and associative models will be used to evaluate growth of natural- and hatchery-origin fishes from each release site and watershed.

The genetic samples will be analyzed using microsatellite and/or allozyme analysis to determine the genetic diversity among returning natural- and hatchery-origin adults, the genetic distance between natural- and hatchery-origin adults, and the effective population size of the natural-origin adults within the Umatilla subbasin.

Status: Monitoring of hatchery-origin steelhead that stray into the Umatilla River is conducted by the BPA-funded Umatilla Hatchery Monitoring and Evaluation Project. Genetics samples are collected by the Umatilla Natural Production Project, with samples processed by Columbia River Inter-Tribal Fish Commission fish geneticists.

Objective 5: Identify and assess factors limiting viability of Umatilla River steelhead.

Limiting factors analysis is the process by which factors affecting population productivity, capacity, diversity and spatial structure are identified. As conditions are improved through management actions, and limiting factors are addressed, it is essential to re-assess limiting factors to guide future actions. This objective addresses Critical Uncertainty number seven. This is a high priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- What environmental factors limit steelhead productivity in the Umatilla subbasin?

Approach: We have developed an improved version of EDT and AHA (All-H Analyzer) which is more representative of Oregon's Mid-C steelhead. The revised EDT model will be updated in the future as habitat actions begin to improve conditions and additional data are available. We will use the EDT model to re-assess limiting factors.

Analysis: Limiting factors and the capacity of the Umatilla subbasin will be analyzed every five years as part of regular evaluation activities. A multi-factor spatially explicit model (EDT and improved AHA) of the Umatilla subbasin will be used to estimate mortality in Umatilla, Columbia, and marine life-history stages.

Status: Ongoing, but will need additional funding for the future.

Objective 6: Determine the status and trend of current and historically utilized salmonid habitat in the Umatilla subbasin.

This recovery plan identifies a set of management actions that will increase natural production and harvest opportunities in the Umatilla subbasin through habitat restoration and protection, flow augmentation, passage restoration, and hatchery supplementation. There are a number of habitat-based RM&E information needs that must be addressed if the benefits of these management actions are to be effectively detected with sufficient power. Information from this objective addresses Critical Uncertainty number seven. This is a high priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- What is the status and trend in steelhead habitat quantity and quality throughout the Umatilla subbasin?
- What are the spatial distribution and quantitative features of Umatilla subbasin steelhead habitat?

Approach: A variety of complementary habitat monitoring activities are regularly conducted in the Umatilla subbasin to capture variance in physical, biological, and chemical conditions. The sampling regime of these activities has varied from continuous monitoring of flow and temperature, to decadal monitoring of riparian conditions. Monitoring has focused on factors that are not primarily controlled by upstream conditions so that measurable improvements can be detected in important elements of salmon habitat. Habitat recovery will primarily be measured in terms of regrowth of the riparian vegetation, vegetation and channel structure, and in-stream cover. In addition, vegetative recovery is related to improvements in bank stability and channel morphology, therefore geomorphic characteristics will also be monitored. These broader parameters, though not useful for project specific monitoring, are more important when tracking comprehensive subbasin-wide recovery. The spatially explicit sampling approach (EMAP) of all known spawning and rearing areas is recommended for sampling the known spatial extent and status and trend of steelhead habitat in the Umatilla subbasin. Representative sites within the subbasin are sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. Habitat variables follow ODFW Aquatic Inventories design (Moore et al. 2002) and are measured at the unit and reach scale.

Analysis: Data are analyzed as distribution data in a GIS format. Sample sites are associated to specific major spawning and rearing areas. Database and GIS formatting of data allow associations with land use, land vegetation coverage, and many other attributes at watershed and population scales.

Status: BPA currently funds two Umatilla River Anadromous Fish Habitat projects; one managed by ODFW to improve and monitor habitat and the other managed by CTUIR to

increase our understanding of the spatial arrangements of physical processes that create and maintain critical habitats for Pacific Salmon in the Umatilla River basin and nearby basins.

Objective 7: Determine the influence of the current hatchery supplementation program on the natural population.

The reproductive success and genetic characteristics of hatchery-reared fish can be different from those of naturally-reared individuals or populations (Reisenbichler and McIntyre 1977). These differences stem in part from the environment of hatcheries, and in part from the artificial selection associated with the hatchery environment. The problem can in theory impact population growth (productivity of the natural-origin population) even when endemic stock is used and traditional stock domestication is avoided (Chilcote 2003; Reisenbichler et al. 2003). This objective provides information that addresses Critical Uncertainty numbers five and six. This is a high priority objective.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- Does supplementation alter the life history or genetic characteristics of the natural steelhead population?
- To what extent will supplementation enhance natural production of summer steelhead?
- Are residualization rates of hatchery releases greater than those of naturally-spawned fishes?
- Do the ecological relationships of hatchery-reared steelhead negatively impact naturally-reared steelhead?

The goal of supplementation is to enhance natural production by increasing survival of hatchery-origin fish, resulting in an increase the number of spawners in natural environments. However, the artificial propagation of fish and manipulation of breeding structures includes genetic risks that may compromise the goal of supplementation (Currens and Schreck 1995).

The hatchery supplementation program is managed to minimize potential unintended impacts on the life history characteristics of the native steelhead population. It is assumed that the use of natural-origin fish for broodstock will result in hatchery fish that mimic the behavioral characteristics of native fish, thus minimizing potential unintended impacts of the supplementation program. Since no pre-supplementation life-history information is available for pre- and post-supplementation comparisons, managers need to rely on long-term monitoring to detect shifts in native steelhead life history. However, the challenge of this approach is distinguishing whether these shifts are attributable to natural variability or hatchery supplementation.

Hatchery-origin fish are usually released at sizes and conditions which differ from their natural-origin counterparts. Sexually mature residualized fish can compete with returning anadromous adults for mates, and can compete with resident fish or pre-migrant juveniles for ecological resources. Recent studies by the Yakima-Klickitat Fisheries Program suggest that hatchery practices can be modified to decrease residualization rates if problems are detected.

Similar work should be conducted to determine the extent and impacts of hatchery fish residuals on the natural population.

Potential unintended negative impacts of hatchery supplementation to the life history and genetic characteristics of the endemic steelhead population in the Umatilla subbasin is a primary management concern. The management strategy for reducing risk of unintended impacts to the natural-origin steelhead population is to implement hatchery production protocols that maximize life history and genetic diversity of hatchery-origin steelhead. If protocols achieve their goal, smolt migration and adult life history characteristics expressed by hatchery-origin steelhead should mimic those of natural-origin steelhead, and reduce the risk of unintended impacts to the natural-origin steelhead population when hatchery-origin steelhead spawn naturally.

Ideally, assessing whether hatchery supplementation negatively impacts life history and genetic characteristics of the naturally population is best accomplished by a pre/post supplementation comparison of these characteristics. However, no pre-supplementation data are available to provide a baseline for pre/post comparisons. Therefore, the approach should be to monitor life history characteristics and assess whether smolt and adult life history and genetic characteristics expressed by hatchery-reared steelhead are similar to those expressed by naturally-reared steelhead and detect changes if they occur. These data can be used to assess population viability by measuring life history diversity.

The Umatilla Fish Hatchery has used endemic steelhead stock for more than a decade. Nonetheless, it is not possible under the current RM&E approach to validate the long-term success of hatchery-origin fishes, or to estimate the relative reproductive success of hatchery- or natural-origin individuals. Due to increasing concern for the welfare of endemic populations, the reproductive success and genetic characteristics of Umatilla steelhead remains a critical uncertainty. Pedigree studies are being used in a variety of subbasins to answer a number of questions. These endeavors are costly and resource intensive, but may provide essential management information. Pedigree studies can demonstrate the relative productivity of natural and hatchery fish in the environment and aid in determining the effectiveness of a supplementation program.

Approach: Polymorphic microsatellite loci have been used in a variety of studies to determine parentage and population structure (O'Reilly et al. 1998; Bernatchez and Duchesne 2000; Letcher and King 2001; Eldridge et al. 2002). The technique and its application have been thoroughly reviewed (Wilson and Ferguson 2002). Microsatellite analysis can be used to estimate the relative reproductive success of natural- and hatchery-origin steelhead, the long-term reproductive success of hatchery-origin steelhead, and the genetic characteristics of both stocks.

Two parallel studies have been proposed for the evaluation of long-term reproductive success at the watershed level. A weir is planned for the mouth of Iskuulpa Creek to sample returning adult steelhead. Adult anadromous returns, resident redband trout, and juvenile progeny will be sampled and genotyped for 16 microsatellite markers. This sampling regime will be followed for ten years, the completion of two full steelhead generations. This

pedigree analysis will be used to assess and compare the relative and long-term reproductive success of hatchery x hatchery (H x H), hatchery x natural (H x N), and natural x natural (N x N) crosses from Umatilla Mid-C summer steelhead.

In addition the testing of a new technique for the evaluation of progeny parentage is currently proposed. Hatchery-origin female returns will be injected with strontium chloride hexahydrate ($SrCl2 \cdot 6H2O$) in solution. This will serve as a mark of hatchery female parentage. These injections have been shown to elevate progeny Sr/Ca ratios in the otolith primordia. A subsample of progeny above the weir would be sacrificed, and their otoliths extracted. The proportion of "elevated" vs. normal Sr:Ca ratios would be used to estimate the fraction of offspring from hatchery- vs. natural-origin mothers.

We have completed an initial analysis to assess if nearby unsupplemented populations in the John Day Basin can serve as reference populations for the Umatilla supplementation monitoring. There is a high degree of correlation in the pre-hatchery treatment time period between Umatilla steelhead and the John Day populations for both abundance and productivity. We will use the John Day populations as reference populations to assess changes in abundance and productivity that result from the long-term hatchery supplementation program.

Residualized steelhead are currently planned to be sampled during EMAP surveys. Residuals would be classified based on the presence of a fin clip or wire tag for hatchery fish. Their distribution and abundance should be measured across the Umatilla watershed.

We will monitor and compare smolt and adult migration timing, ocean residency age structure, and adult sex ratios of natural- and hatchery-origin steelhead. Migration timing of steelhead smolts will be monitored via detection of PIT-tagged fish at TMFD, John Day, and Bonneville dams. Adult run timing of steelhead to the Umatilla River will be monitored by trap and video enumeration at TMFD and in-subbasin creel surveys below TMFD. Ocean residency age structure and adult sex ratios of steelhead will be monitored during adult trapping and handling operations at TMFD.

Ocean residency age and sex ratios of natural- and hatchery-origin adult steelhead are monitored during trapping at TMFD. Migration timing of natural- and hatchery-origin steelhead smolts is compared by calculating the percent of the run that passes TMFD, John Day, and Bonneville Dams on a weekly basis, and testing for a statistically significant difference. The same method is used to compare migration timing of natural- and hatchery-origin adult steelhead that pass TMFD. The proportions of the natural- and hatchery-origin runs that were one- and two-year ocean residents, male and female, and male and female by ocean age will also be compared.

Analysis: Umatilla adult steelhead samples are analyzed by the Columbia River Inter-Tribal Fisheries Commission cooperative genetics program at the Hagerman Fish Culture Experiment Station using microsatellite loci that have been optimized for steelhead studies. Juvenile samples are analyzed by NOAA Fisheries as a part of the Columbia basin-wide genetic monitoring program. Samples are analyzed for each brood and return year.

Genotypes are assembled using 16 microsatellite markers. Parentage is estimated using a variety of exclusion, likelihood, pair-wise relatedness, and genetic similarity algorithms (Wilson and Ferguson 2002). The relative and long-term reproductive success of hatchery x hatchery (H x H), hatchery x natural (H x N), and natural x natural (N x N; including steelhead x steelhead and steelhead x redband trout) crosses will be evaluated in the controlled escapement experiment in Iskuulpa Creek.

Status: Partially funded by BPA and implemented by CTUIR and ODFW.

Objective 8: Monitor and assess the impact of flow enhancement on steelhead survival, habitat, and migration.

Considerable effort and resources are directed at flow restoration in the Umatilla River. Umatilla flow management programs are considered a Columbia Basin success story due to the cooperative efforts between CTUIR, BLM, and the various water-rights managers in the subbasin. However, some of the direct benefits to fish have not been quantified. While the relationships between flow restoration and trap-and-haul work are comparatively straightforward, the relationship between increased flow and increased spawning and rearing habitat has not been directly studied. Additional flow restoration activities including the Phase III flow exchange project are receiving considerable attention. Baseline effectiveness monitoring is needed to understand the added benefits to fish that these future flow programs would bring to the subbasin. This objective provides information that addresses Critical Uncertainty number seven. This is a high priority objective due to the cost and scale of the flow enhancement efforts.

Type of monitoring effort: Effectiveness monitoring.

Monitoring questions:

- What is the impact of flow enhancement on steelhead survival and frequency of steelhead transport?
- What is the effect of flow enhancement on the availability of spawning and rearing habitat?
- What is the effect of flow enhancement on steelhead migration?

A major passage restoration project is planned for the Umatilla Mainstem at Feed Canal (Harza Engineering Company 1999). Experience has shown that not all passage restorations are successful, so project effectiveness monitoring is warranted upon completion of construction and beginning of operations. The efficacy of two additional fish passage facilities, the Boyd Hydro and Maxwell Dams, is uncertain due to a lack of data associated with these recently renovated structures. Passage at these facilities needs to be evaluated.

Adult and juvenile fish passage facilities at irrigation diversions in the Umatilla mainstem were reconstructed from 1988 to 1994. Effectiveness of the updated facilities has previously been evaluated. Juvenile passage evaluation was conducted by ODFW (Knapp and Ward 1990; Knapp 1992; Cameron and Knapp 1993; Cameron et al.1994, 1995, 1997; Walters et al. 1994), adult passage evaluation was conducted by CTUIR (Kutchins 1990; Kissner 1992,

1993; Volkman 1994, 1995; Contor et al. 1996, 1997), and Nigro and Ward (1986) evaluated channel modification below Three Mile Falls Dam. These studies identified two passage impediments in the Umatilla mainstem and recommended potential corrective measures.

Performance metrics: Percent of juvenile and adult returns which pass through the lower river volitionally, during enhanced flows, and those requiring transport, survival from TMFD to spawning, and spawning distribution.

Approach: We will monitor and report the percent of juvenile and adult returns which pass through the lower river volitionally, during enhanced flows, and those requiring transport. This computation will include an adjustment to account for transit time from enumeration at TMFD to when their migration through the flow-enhanced river reach is completed. These adjustments will be based on estimates of juvenile and adult migration speeds available from adult radio tracking studies conducted from 1994-1996 (Volkman 1994 and 1995, Contor et. al 1996 and 1997) and smolt migration monitoring from the recently funded smolt outmigration and monitoring project..

Logistical difficulties impede assessment of survival benefits from flow enhancement for smolts migrating through the lower Umatilla River. A potential approach for assessing benefits to smolt migrants is a tier III treatment and control experiment, where the treatment is smolts volitionally migrating past the juvenile trapping and transport facility at RM 27 during flow enhancement and the control is smolts trapped at RM 27 and transported to the river mouth (simultaneous to tagging of treatment fish).

Juvenile habitat utilization and summer steelhead spawning will be monitored in the Umatilla mainstem during annual EMAP surveys. Summer stream temperatures will be monitored in collaboration with BOR and CTUIR water quality programs. Habitat quantity will be monitored continuously as a function of stream flow throughout the supplemented reaches of the Umatilla River.

Adult steelhead could be collected and radio-tagged at TMFD using standardized handling techniques. Fixed site radio telemetry receivers would be placed at key passage barriers to monitor migration around these obstructions. Baseline estimates of passage and delay are available for various flow regimes (Contor et al. 1995, 1996, 1997, 1998).

Analysis: Habitat potential will be modeled regularly using a spatially explicit model of habitat quality and quantity such as EDT, facilitating the evaluation of the relative impacts of various flow management regimes, including the implementation of Phase III flow exchange.

The benefits of flow augmentation will be analyzed based on comparative performance of the lower and middle Umatilla mainstem reaches as indicated by habitat, rearing, and spawning metrics. Data collected will be compared to the baseline data to evaluate the effectiveness of the passage restoration projects.

Status: BPA funds the CTUIR managed Umatilla Fish Passage Operations project, which collects data on juvenile and adult steelhead passage in relation to flow. BPA also funds the

ODFW managed Umatilla Smolt Outmigration and Survival Project. Monitoring of adult steelhead migration past potential barriers, using radio telemetry, occurred in 2008 and 2009, Funding is needed to investigate relationships between flow and juvenile habitat use.

Objective 9: Determine the effect of mainstem hydropower operations and operational improvements on viability of Umatilla River steelhead population.

This is a high priority objective.

See John Day MPG for *Timeline, Monitoring Questions, and Approach*.

Objective 10: Determine the effect of harvest on the abundance, productivity, diversity, and distribution of the natural-origin population.

Restoring and optimizing fishery opportunities are a primary goal of local and regional fishery managers. However, this can be a challenging due to changes in fishing effort, run sizes, catch and harvest that are likely to occur as environmental and anthropogenic conditions vary and the fisheries restoration program matures. In addition, fisheries are also managed to keep unintended impacts to natural and hatchery production and non-target species within acceptable limits. This objective addresses Critical Uncertainty number four. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What is the annual harvest rate that occurs outside of the Umatilla River subbasin?
- Do summer steelhead return at a level of abundance adequate to support annual fisheries?
- What is the annual harvest rate that occurs within the Umatilla River subbasin?
- What is fishing effort, catch, and harvest for tribal and non-tribal fisheries in the Umatilla River?
- Are harvest goals met and do management actions optimize fishing opportunities while meeting production and population objectives?

Much of the impetus for the Umatilla supplementation and reintroduction programs are tribal and non-tribal harvest mitigation. Steelhead fisheries take place throughout most of the mainstem Umatilla River using a diversity of fishing gear. Tribal fisheries mostly occur upstream within the CTUIR Reservation and consist of a subsistence fishery using gaffs or dipnets and a recreational fishery using rod-and-reel. Non-tribal fisheries occur from Pendleton downstream to the river mouth using rod-and-reel, with most effort, catch, and harvest concentrated below TMFD. Creel data provide information needed to determine whether harvest goals are achieved or exceeded, enumerate fish removed from the run below TMFD, and assess how to optimize fishing opportunities through adaptive management. Accurate run size predictions allow managers and program staff to plan appropriate broodstock collection, harvest, spawning escapement, and CWT recovery strategies in advance. Run predictions are integrated into co-management of the Umatilla Subbasin Fishery Program through the development of an annual plan for hatchery and subbasin

operations. Harvest estimates for Umatilla subbasin-origin fish in out-of-subbasin fisheries provide essential data to track status and trends of fish populations, provide a full accounting of all hatchery production and rearing strategies, compare recruits-per-spawner ratios of natural- and hatchery-origin fish, and evaluate alternative hatchery production and release strategies.

Approach: Out-of-basin harvest contributions are currently grouped by three main fishery areas: ocean, Columbia River, and in-subbasin fisheries. The number of adults harvested by individual hatchery groups and the total number for all hatchery groups by run year are reported. A database of recoveries by brood year contributions is also maintained.

Annual out-of-subbasin harvest is reported for tribal and non-tribal ocean, Columbia River, and subbasin fisheries. In out-of-subbasin fisheries that are selective for hatchery-origin fish, harvest of hatchery-origin fish are estimated from CWT recoveries reported on the Pacific States Marine Fisheries Commission CWT database. In out-of-subbasin fisheries, which are not selective for hatchery-origin fish, harvest of natural-origin fish is estimated based on exploitation rates of hatchery-origin fish.

Tribal fisheries are monitored using roving creel surveys, phone surveys, and volunteer fishing journals. Non-tribal fisheries are monitored using a combination of stratified roving creel surveys and "punchcard" data from anglers who turn in their salmon and steelhead harvest cards. Harvest estimated from creel surveys is used to monitor the developing fisheries in the Umatilla River to assess harvest potential and whether annual harvest goals are met. Overall harvest goals are listed in Table 2 of the Umatilla RM&E plan, and harvest goals for varying run sizes are currently under development. Creel information on spatial and temporal patterns of fishing effort, catch, and harvest are used to assess whether fisheries are optimized within the constraints of natural production and population objectives.

Creel surveys in the non-tribal fishery are composed of three main components: 1) angler counts, 2) interviews to obtain information on catch rate, harvest rate, gear types, and angler demographics, and 3) collection of biological, mark, and CWT information from catch. A roving creel survey is used to count and contact anglers in the steelhead fishery. The lower river is surveyed from September 15 to April 15, and the upper river from January until April 15. Fishing effort is typically very low in the lower river from February through April.

Correlation models have been developed for preseason prediction of steelhead run size to the Umatilla River. Correlations for steelhead ($r = 0.87$) run size to the Umatilla River are based on forecasted steelhead run sizes to Bonneville Dam (Upriver A-run for steelhead). The steelhead model is updated in early-September after the Upriver A-run to Bonneville Dam has been counted.

Analysis: Ratios between punchcard and creel data are used to estimate harvest in the river reach from TMFD upstream to about RM 37 that is logistically difficult to access and survey. Geographically and temporally stratified variance in the tribal and non-tribal catch and harvest estimators are based on the variances of the fishing effort and catch and harvest rates. Effort, catch, and harvest are estimated monthly for steelhead.

Analysis follows Malvestuto (1996) for the field work and Cochran (1977) for creel survey data by expanding subsamples by sample strata and proportional coverage rates. Similar expansions are used to extrapolate tribal wide harvest estimates based on postseason interviews. Catch-per-unit-effort is estimated directly from interview responses and fishing journals. Total fishing effort is estimated based on time period, week period, and site encounter probabilities.

Status: Partially funded by BPA. ODFW has monitored the non-tribal steelhead fishery on the Umatilla River since 1992, and the out-of-subbasin harvest estimates are determined by the hatchery M&E project.

Objective 11: Determine the effect of predation on the abundance, productivity, diversity, and distribution of the natural-origin population.

The objective is moderate priority because predation has not been identified as a key limiting factor.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring question:

- What are the predation rate and predatory impact of introduced fishes in the Umatilla River on juvenile steelhead?

Approach: Annual collections of smallmouth bass and other piscine predators in the Umatilla River could be conducted using angling techniques. Collected stomach samples would be analyzed for the presence of juvenile salmonids. These data could be incorporated into a bioenergetics model to derive a population-level consumption estimate imposed by introduced fishes. Sampling of predatory fish diets should occur during times and locations when and where their distribution overlaps with juvenile steelhead.

Analysis: Interpretation of the predatory impact in the migration corridor should be conducted from methods established in published literature (Ward et al. 1995, Fritts and Pearsons 2006). The proportion of total mortality (e.g. SAR) attributable to predatory mortality could be estimated from bioenergetics modeling results.

Status: Currently unfunded and not implemented.

Objective 12: Monitor production, survival, harvest and spawning of hatchery-origin steelhead.

Monitoring survival and disposition of all hatchery fish through all life stages provides fundamental information required to assess what changes may be needed if management objectives are not met. Information on the magnitude of losses at each life stage also assists managers to determine priorities for changes. Adaptive management actions may involve aspects of the hatchery program or changes to fish restoration programs, harvest regulations, and hydrosystem management within or outside of the Umatilla subbasin.

In 1994, following ESA section 7 consultations concerning the effects of straying by non-native hatchery-origin fish, NMFS set an interim standard to limit stray, non-native hatchery-origin fish to 5% of any naturally spawning population (Grant 1997). To achieve this management standard and provide the necessary information needed to develop risk containment strategies for straying, all hatchery production which has the potential to stray into spawning areas of ESA-listed populations needs to be adequately marked, and monitoring programs must be present in ESA areas to recover marked fish. In addition, adaptive management of the Umatilla subbasin fisheries restoration program may have potential to reduce straying by adjustments in the timing of flow enhancement, and increased capabilities for flow enhancement if Phase III water exchange is implemented. This M&E objective is focused on providing information needed to monitor standard hatchery production goals, adaptive management of the Umatilla subbasin hatchery program, and straying of hatchery production fish into areas with ESA-listed steelhead populations.

Release sites for smolts in a hatchery steelhead supplementation program are typically located high in a subbasin, in or near tributary streams that are targeted for supplementation. In contrast, harvest oriented hatchery programs typically release steelhead smolts in lower mainstem reaches of a subbasin. In the case of the Umatilla subbasin steelhead supplementation program, hatchery smolt releases in Meacham Creek are intended to provide the Meacham Creek spawning aggregate with additional hatchery-reared spawners. Hatchery smolt releases into the Umatilla mainstem lower in the subbasin at Minthorn (RM 64) and Pendleton (RM 56) have a dual harvest-supplementation intent. They are intended to enhance fisheries in the upper Umatilla mainstem while providing "Middle Umatilla" tributaries with additional hatchery-origin spawners.

The Birch Creek watershed is managed as a native steelhead sanctuary. Adult escapement was monitored for a number of years by CTUIR and ODFW, and fraction was consistently less than 5%. Periodic monitoring of spawning escapement to Birch Creek is warranted to determine if straying and the hatchery fraction remain at low rates. This is a high priority objective because of the assumed benefits and high degree of uncertainty in the management action.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- Are hatchery returns achieving the goals of the comprehensive plan?
- Are recruits-per-spawner ratios higher for hatchery-origin compared to natural-origin steelhead?
- What is the number of hatchery-origin returns that stray?
- What percent of returns stray into the Snake and upper Columbia River basins?
- Does hatchery supplementation result in increased natural production of steelhead?
- What proportion of steelhead spawners in the Umatilla subbasin is derived from the hatchery program, and what is their distribution?

Performance metrics: For all hatchery production and release strategies: annual numbers of smolts produced, smolt-to-adult survival by brood year; number of adults produced by brood

year, annual number of adult returns, and annual and brood year harvest and number of natural spawners.

Approach: Routine in-hatchery production and survival is monitored by hatchery staff and reported to the statewide ODFW hatcheries database. This M&E objective primarily describes monitoring activities conducted outside of the hatchery. Survival of hatchery-origin fish during the smolt migration life stage is currently monitored by detection of PIT-tagged smolts in the lower Umatilla River and at John Day and Bonneville dams in the Columbia River. Adult production, SAS, harvest, and straying of all hatchery production and release groups are monitored using CWTs. Adult returns to the Umatilla subbasin for all hatchery production and release groups are monitored using CWTs recovered within the subbasin.

Repeated spawning ground surveys could provide a future measure of the presence of hatchery (fin-clipped) steelhead in the Birch Creek watershed during the spawning season. While actual fish observations may be low, repeat spawning ground surveys on the John Day River have demonstrated that visual surveys are feasible. This approach is much more logistically and financially feasible compared to the operation of a new weir and adult trap.

Rearing and release history of hatchery steelhead returns to the Umatilla subbasin is monitored using CWTs recovered from all locations within the subbasin. Of particular regional interest is the identification of non-Umatilla origin hatchery groups that enter the Umatilla River in spring that will likely spawn with ESA listed Umatilla steelhead.

Recruits-per-spawner ratios of hatchery-origin steelhead over time must be substantially higher than those of natural-origin steelhead for hatcheries to be a viable tool for fisheries restoration. If this is not the case, more adult production will be realized by leaving hatchery broodstock in the river to spawn naturally. The number of additional adults produced by hatchery programs also must be great enough to overcome potentially lower productivity (reproductive success) when they spawn naturally compared to natural-origin fish.

Numbers of adult parents will be known from spawning records for hatchery-origin fish, but will require estimation for natural-origin steelhead. Spawning information is documented in annual reports produced by the CTUIR Umatilla Hatchery and Satellite Facilities O&M Project (BPA Project # 83-435). Numbers of natural-origin parents are from counts at TMFD. Adult progeny from a brood will return over multiple years. Number of progeny per brood for hatchery-origin fish is estimated from abundance and age information acquired by CWT recoveries. Number of progeny per brood for natural-origin steelhead that return to TMFD is estimated by collecting scales for age analysis to apportion adult returns by brood year. Numbers of natural-origin steelhead harvested in non-selective fisheries is estimated by creel surveys for Umatilla subbasin fisheries and by using CWT recoveries of harvested hatchery-origin fish as a surrogate for harvest of their natural-origin counterparts in out-of-subbasin fisheries. For out-of-subbasin harvest, it is assumed that the age classes of the natural-origin fish harvested out-of-subbasin are equal to the age composition of returns to the Umatilla River. Monitoring straying of adult steelhead from the Umatilla subbasin

hatchery is conducted by marking steelhead with a CWT and analyzing out-of-subbasin CWT recovery data.

Analysis: Up until 2004, in-basin survival of hatchery salmonids was estimated using the Migrant Abundance Method (Burham et al. 1987 and Dauble et al. 1993). Commencing in 2005, in-basin and out-of-basin survival for natural and hatchery steelhead was estimated using the CRISP and SURPH models. The Umatilla Outmigration and Survival study is no longer funded, thus these estimates are not currently available.

Testing for significant differences in survival rates is conducted annually and over five-year periods. Smolt survival estimates generated by SURPH include a point estimate and associated variance.

Relative survival of PIT tagged groups from valid comparisons to TMFD, and John Day and Bonneville Dams were compared in the past. PIT tag information is currently submitted and recovery data obtained from the PSMFC database. Number, travel time, and length at PIT-tagging are recorded for each release group at all reporting observation sites.

To determine number of adult progeny produced per brood for natural- and hatchery-origin steelhead, calculate P:P ratios for both natural- and hatchery-origin fish as total number of adult progeny produced divided by total number of adult parents that spawned.

Numbers of adults which are recovered at terminal locations outside of the Umatilla subbasin (spawning grounds, hatcheries, and adult traps) can be reported for the following areas: Snake River Basin, Columbia River Basin above McNary Dam, Columbia River Basin below McNary Dam, and all other locations. No steelhead with CWTs have been recovered at out-of-subbasin terminal locations to date.

Status: Partially funded by BPA.

Objective 13: Determine the transmission and effect of disease on the abundance, productivity, diversity and distribution of the natural-origin population.

The overall goal of the fish health program is to release fish into the Umatilla subbasin that are known to have a healthy disease history during rearing to minimize impacts on naturally- and other hatchery-reared fish. This is a low priority objective because disease effects have not been identified as a limiting factor.

Type of monitoring effort: Long-term status and trend monitoring.
Monitoring questions:

- What are the prevalence and level of pathogens in natural- and hatchery-origin steelhead?
- What are the magnitude and pathways of disease transmission between hatchery- and natural-origin steelhead?
- What is the prevalence of whirling disease in the Umatilla River basin, and what is its influence on the natural steelhead populations?

Performance metrics: Pathogen prevalence and levels in natural- and hatchery-origin steelhead.

Approach: The health of hatchery-origin fish should be monitored starting with broodstock and continuing through rearing and release of juveniles. Natural fish health is assessed on mortalities encountered during parr, smolt, and spawner monitoring activities. If possible, all sampling, diagnostic, and statistical analyses will conform to the Integrated Hatchery Operations Team and the Pacific Northwest Fish Health Protection Committee guidelines. All monitoring is consistent with the ODFW fish health policy and the native fish conservation policy.

All raceways of each species and stock at Umatilla Hatchery are monitored monthly for fish health. Monthly monitoring consists of examining five fresh-morbid or moribund fish from each raceway for systemic and gill bacteria on TYE-S agar. In addition, monthly inspections include microscopy of gill tissue and body scrapings for parasites and gill condition from a minimum of five fish. Sixty fish are tested annually for *Myxobolus cerebralis,* the causative agent of whirling disease. Within four weeks of transfer from the hatchery, tissues from grab-sampled fish are examined for virus on cell cultures from a minimum of 10 fish per raceway. Gill and body scrapings are examined by microscopy from a minimum of three fish per lower raceway at Umatilla Hatchery. In addition, prior to their liberation from acclimation facilities most groups of fish are examined from each acclimation pond as in the monthly monitoring protocols described above.

A minimum of 60 broodstock fish are examined for culturable viruses as per fish health section bluebook methods. This includes ovarian fluid and pyloric caeca/kidney/spleen samples from all broodstock for this program. All broodstock mortalities are examined for culturable systemic viruses using TYE-S agar.

Currently, fish health personnel examine naturally-reared fish that are submitted for analysis. Submissions consist of mortalities from naturally-reared juveniles obtained from smolt traps and parr collected during juvenile fish sampling. Disease examinations include testing for *M. cerebralis,* IHNV, and other culturable viruses.

Analysis: Analysis of samples will follow standard protocols defined in the latest edition of the American Fisheries Society "Fish Health Blue Book" (Procedures for the Detection and Identification of Certain Fish Pathogens).

Status: Partially funded by BPA, partially implemented.

13.3.2 Walla Walla River Population

Summer steelhead are currently the only natural population of anadromous fish in the Walla Walla subbasin. Steelhead restoration and management programs in the Walla Walla subbasin include hatchery actions, harvest management, and habitat, flow, and passage improvement projects. Artificial production programs for steelhead include a Lyons Ferry Hatchery steelhead harvest mitigation program and an experimental endemic steelhead mitigation program in the

Touchet River population. The "Comprehensive Aquatic Research, Monitoring and Evaluation Plan" (RM&E plan, Appendix AD3 in the Walla Walla Subbasin Plan) outlines a strategy for obtaining information needed to assess the performance and evaluate the success of these restoration programs.

The research, monitoring, and evaluation objectives and approaches that follow are from the RM&E section of the Walla Walla Subbasin Plan (2004). To date, a comprehensive Walla Walla subbasin RM&E plan, including critical uncertainties, has not been agreed upon by all agencies, however research priorities are listed in the Subbasin Plan and in this report. Some of the monitoring and evaluation activities described in this plan are ongoing. However, several currently unfunded activities are proposed in this plan to address key information gaps and improve ongoing efforts. These proposed activities include modification of ongoing monitoring, critical uncertainty research, and innovative study approaches.

Status monitoring is performed at multiple scales for summer steelhead in the Walla Walla subbasin. Natural production status monitoring includes abundance indices for juveniles (parr and smolts), number of returning adults, estimated redd numbers, as well as flow, temperature, and habitat data to assess the success of flow augmentation and stream restoration work. Hatchery and natural production evaluations include the monitoring of smolt-to-adult returns, smolt-to-adult survival, catch contribution, catch distribution and straying rates, and experimental releases of juveniles and spawners. Juvenile outmigration monitoring includes the number of outmigrating smolts, travel timing, and survival to downstream dams. In addition, the fisheries are monitored using creel surveys and marine fishery observations to estimate the contribution of Lyons Ferry Hatchery fish to all commercial, subsistence and recreational fisheries.

The objectives of status monitoring are to describe existing habitat conditions and population status, and to assess trends over time. The NOAA Fisheries RM&E plan (NOAA 2003) calls for status monitoring to document progress toward recovery of listed populations. Repeated measurements (temporal replicates) are taken over time to quantify change. Existing population conditions are compared to performance standards as established in the appropriate recovery or master plans.

The Walla Walla EDT model was parameterized during the subbasin planning process without extensive empirical data for the subbasin. In all cases, empirical data were used if available. However many habitat attributes were rated based on local knowledge and best scientific judgment. It is clear that there is significant uncertainty in how well the data represent habitat and fish assemblage conditions. Improving the quality of habitat data is an important step in improving future modeling efforts. Improved data quality can be achieved by collecting additional empirical data and future efforts should focus on the following recommended attributes.

1) Those attributes with the greatest importance in EDT model results (e.g. maximum width, gradient, habitat type inventories, large wood, bed scour).
2) Those that are within the priority protection or restoration stream reaches identified in Section 9.

3) Data that are limited for attributes which have a broad (subbasin wide) effect on population or habitat status (passage at obstructions, water quality, others).
4) Attributes identified as primary limiting factors in Section 8.

The general M&E framework for the Walla Walla subbasin is guided by the need to fill data gaps and establish a better understanding of the baseline habitat conditions including the characteristics of passage, flow, substrate and ecological interactions which most directly impact the production of steelhead. The overall goal of monitoring and evaluation efforts will be to address, at a minimum, those critical areas for VSP analysis as described by NOAA Fisheries. Specific performance measures were identified for the four VSP areas:

1) *Adult abundance*: Run size to the basin (this can be greatly impacted by out-of-subbasin effects but is critical to monitoring population status). Estimates or enumeration of escapement to the spawning grounds including hatchery fish and harvest within the subbasin (hatchery harvest and incidental hooking mortality of natural-origin fish). Out-of-basin harvest and mortality may limit recovery.

2) *Juvenile:* Smolt production at the population scale to reflect freshwater survival and production within the basin. It will be critical in modeling population response to habitat restoration actions.

3) *Diversity:* Genetic characterization, phenotypic diversity, life history pathways (juvenile and adult), and artificial propagation effects (hatcheries).

4) *Spatial Structure:* Distribution of juveniles and adults within the population, habitat limiting factors by life stage.

5) *Productivity:* Population growth rate or potential – smolts per spawner, natural-origin recruits-per-spawner, and population growth rate.

Monitoring of these key VSP parameters and their various performance metrics is described in the RM&E objectives that follow.

Objective 1: Monitor and assess the status and trends of abundance and productivity of hatchery- and natural-origin steelhead.

Adult abundance estimates to the Walla Walla River population are a critical metric for monitoring the status and long-term trends of this steelhead population. Monitoring trends in the performance metrics listed below will be critical to assessing the performance of the Walla Walla subbasin fish restoration program. These measures will also be used in viability analyses to estimate productivity and natural production capacity. Adult monitoring in the Walla Walla River is limited by the absence of a trap or ladder near the mouth of the river. Therefore, total returns to the Walla Walla River population are estimated from counts at Nursery Bridge and expansions of these counts to unsurveyed areas in the remainder of the population. Expansions are based on habitat capacity relationships and there is considerable uncertainty. Traps exist in

the middle-upper reaches of each drainage. Facilities at the Bennington Dam fish ladder require improvements to function for effective fish enumeration. This is a highest priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What is the annual steelhead spawner abundance in the Walla Walla and Mill Creek watersheds?
- Is the 10-year GM of natural-origin steelhead spawners in the Walla Walla population greater than or equal to the recovery criteria for natural-origin spawners?
- What are the current and trend in the 20-year population growth rate?
- What are the current and trend in smolts/spawner?
- What are the current and trend in adult spawner-to-spawner ratios?

Performance metrics: Number of hatchery- and natural-origin adult spawners in the Walla Walla population, run timing of hatchery- and natural-origin adult returns, smolts-per-spawner, adult spawner-to-spawner ratios.

Approach: Numbers of adult hatchery- and natural-origin returns will be enumerated by trap counts, as well as by visual redd surveys. Current traps/monitoring stations in the basin include Nursery Bridge, Bennington Dam ladder, and the Yellowhawk fish weir. A complete count of escapement past these locations could be obtained, but several of the facilities require improvement.

CTUIR will sponsor a design investigation to study the feasibility and technical requirements of placing a video-sonar adult monitoring system at or near the mouth of the Walla Walla. The study will cover design and maintenance requirements for a system, and will recommend best-available technology for such a system. If implemented the system would greatly aid management in understanding total abundance of adult returns to the Walla Walla, run timing and environmental correlates of migration in the lower river. In addition, CTUIR will work with USACE to improve fish monitoring equipment and protocols on Bennington Dam as described by Tice (2004). Improvements may include the use of visual, sonar, and lasers to acquire a more complete count of fish passing the facility.

Analysis: Counts of adult returns in combination with other metrics described in later M&E objectives (harvest, straying, spawner abundance, and smolt outmigrant abundance) will be used to estimate key metrics of abundance, survival (smolt-to-adult survival, pre-spawn mortality) and productivity (smolts-per-spawner, adult spawner-to-spawner ratios).

Status: Partially funded, ongoing.

Objective 2: Monitor and assess the distribution and density of spawners and juveniles.

An understanding of spatial and temporal variance in both spawner and juvenile production and productivity is necessary to estimate a variety of performance measures. Improved accounting of adults into the upper Mill Creek is needed. This is a highest priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What are the annual distribution and abundance of spawners and redds in each watershed?
- What are the spatial distribution of the occupied spawning areas and density of spawners within the population boundaries?
- What are the current spatial extent and distribution of rearing habitat used by juvenile steelhead?
- What are the relative abundance and distribution of juvenile steelhead, by age, seasonally throughout the basin?

Performance metrics: Spawner spatial distribution, spawn timing, and rearing distribution.

Approach: Sampling will be conducted for steelhead within their spawning and rearing habitat. The sampling design will follow a modified EMAP protocol. Spawner surveys will be randomized by tributary and reach for randomly selected reaches. Index reaches have been established for most of the subbasin. Juvenile surveys will be randomized by watershed, or stratified where randomization is undesirable. Annual estimates of density will be produced for each life-history stage, watershed, and at the population-scale.

Electrofishing, seining, and trapping will be used to quantify the abundance of juvenile salmonids at the reach scale. The sampling universe for juvenile surveys will be the EDT reaches developed for subbasin planning. We will use these reaches and watershed delineations to allocate sampling across the subbasin.

Instead of attempting to populate traditional statistical models, we will use a geostatistical estimator of population variance to project juvenile stock assessments across watersheds based on annual juvenile fish surveys. We will survey permanent index sites in each target watershed using multiple pass depletion electrofishing, snorkeling, and seining between barrier nets. Habitat conditions of the index sites will be estimated every 3 to 10 years, and the wetted width and volume of each site will be determined annually. An additional 2-5 sites will be randomly selected using a spatially balanced algorithm (Stevens and Olsen 2003, 2004). Within each reach sampling sites will be distributed randomly where possible, but will conform to landowner requests and trespassing laws. Fish communities and habitat information will be sampled at each randomly selected site. A draft site selection is currently under development and review by EPA's EMAP laboratory for the Walla Walla subbasin. Thirty permanent index sites and at least an additional thirty randomly selected sites will be sampled each year. This sample size approaches the practical maximum for field efforts, surpasses the sample size required to detect geographic patterns in community structure related to habitat variability, far exceeds the sample size needed to detect changes in each watershed (Roper et al. 2003), and should be sufficient to detect a 50% change in salmonid densities per annum at the watershed scale. Approximately five to ten percent of the catch will be PIT-tagged for survival and outmigration monitoring. This will provide a sample for the assessment and monitoring of within-subbasin survival of salmonids using detections at Columbia River PIT-tag detectors and the within-subbasin rotary screw traps.

Spawner surveys will be conducted during the appropriate spawning and holding season. Effort will be allocated using a stratified randomization of EDT reaches based on known and historical spawning habitat. Redds will be enumerated as an index of spawner abundance using multiple-pass visual surveys of the spawning grounds. The location of each redd will be georeferenced. The condition of each redd and any observed spawner activity will be noted. Each observed redd will be flagged by marking tape on adjacent vegetation to avoid re-sampling.

Steelhead survey efforts will be stratified using index sites that have five- to ten-year datasets. Each site will be visited annually and receive at least three passes each year. An additional two to six randomly selected reaches will be surveyed annually using multiple-pass visual observations. The co-managers are currently working to develop a rolling panel or continuous survey methodology for summer steelhead and bull trout.

Analysis: A geostatistical analysis will be conducted using population and habitat data to estimate fish-habitat relationships and to produce a geostatistical stock assessment of spawners and juveniles. Associative and trend analyses will be used to monitor changes in spawner and juvenile populations.

Status: Spawner monitoring is funded and ongoing; juvenile surveys are funded and implemented.

Objective 3: Monitor and assess the abundance, timing, life history characteristics, and in-stream survival of out-migrating steelhead.

An estimate of smolt abundance for natural-origin steelhead in the lower Walla Walla River is essential to answering critical uncertainties surrounding natural production capacity and within-subbasin productivity. In addition, an understanding of migration success and survival is necessary to identify in and out-of-subbasin limiting factors (including environmental conditions, flow, fish habitat, hatchery rearing and release strategies, predation, and passage difficulties) and estimate loss by life stage for hatchery- and natural-origin fish. This is a highest priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What are the abundance, timing, and in-stream survival of out-migrating steelhead?
- What are the life history characteristics of out-migrating steelhead?

Performance metrics: Migration parameters, abundance, survival, and life history characteristics (including age, size and condition) of emigrating smolts or migrants.

Approach: Total population smolt abundance will be estimated for natural-origin steelhead emigrating from the Walla Walla River using a rotary screw trap. In addition, estimates of outmigrant abundance will be obtained for the upper Walla Walla and Mill Creek rivers using rotary screw traps. The Bootstrap method with 1,000 iterations will be used to derive a

variance. Smolt survival and migration parameters (timing, duration and travel speed) will be monitored for hatchery- and natural-origin fish using PIT tags and remote interrogation at the lower screw trap and Columbia River dams.

Environmental variables including water discharge, flow, temperature, and water clarity in the lower river will be monitored. Juvenile life history characteristics including smolt emigration timing, length, age, health, condition and smolt status will be collected.

Analysis: Smolt survival estimates will be calculated using the Migrant Abundance Method (Burham et al. 1987 and Dauble et al. 1993) and the SURPH 2 model (http://www.cbr.washington.edu/). The binomial test will be used to test for significant differences in detection between comparable release groups of hatchery-reared fish. The relation of environmental variables to smolt survival and/or migration success will be assessed using regression and correlation analyses. Associative and trend analyses will be used to evaluate outmigration.

Status: Partially funded, modification and expansion of ongoing activities are needed.

Objective 4: Monitor and assess the residualization of hatchery- and natural-origin steelhead.

Hatchery-reared fish are released at sizes and conditions that differ from their naturally-reared counterparts. Sexually mature residualized fish can compete with returning anadromous adults for mates, and can compete with resident fish or pre-migrant juveniles for ecological resources. Recent studies suggest that hatchery practices can be modified to decrease residualization rates if problems are detected. The purpose of this work will be to determine the extent and impacts of residualism, whether hatchery practices produce greater-than-natural residualization rates, and to provide some potential corrective measures. This is a moderate priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What is the distribution and relative abundance of hatchery steelhead residuals?
- Are residualization rates of hatchery releases greater than those of natural-origin fishes?

Performance metrics: Residualization rates.

Approach: The WDFW Snake River Lab and Fish Management have annually surveyed (electrofishing) the juvenile production areas of the Touchet River since 2001. Hatchery-origin summer steelhead have been captured and identified (Lyons Ferry stock or Touchet Endemic stock), and residual population estimates have been derived to assess the overall impacts. Juvenile surveys will continue into the future to monitor the residualism rates and their distribution within the watersheds to describe interactions with natural salmonids. In the Walla Walla and Mill Creek system, residualized steelhead will be sampled during juvenile surveys. Residuals will be classified based on the presence of a fin clip or wire tag for hatchery fish, and using outlier analysis for the juvenile population. Resident redband

trout populations will be similarly noted, but are recognized as part of the steelhead population (Currens and Schreck 1995; Kostow 2003).

Status: Work is funded and is currently being implemented, expansion to Walla Walla and Mill creeks is needed.

Objective 5: Monitor and assess the distribution, condition and utilization of essential salmonid habitat in the Walla Walla population.

At the macro- and micro-scales land use and riparian conditions are strongly related to in-stream conditions (Crispin et al. 1993; Stednick and Kern 1994; Chen et al. 1998). These features directly impact water quality conditions, and can alter salmonid production through ecological mechanisms (Torgersen et al. 1999; Ebersole 2002). Habitat impacts are detectable at multiple scales, and can result in decreased survival and production of juveniles (Paulsen and Fisher 2001) and decreased recruitment of spawners (Regetz 2003) at the subbasin scale.
The EMAP of all known spawning and rearing habitats is recommended for sampling the known spatial extent and status and trend of steelhead habitat in the Walla Walla subbasin. Representative sites within the subbasin are sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. Habitat variables could follow ODFW Aquatic Inventories design (Moore et al. 2002) and are measured at the unit and reach scale. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What are the spatial distribution and quantitative features of the Walla Walla population essential fish habitat?
- What is the status and trend in habitat quantity and quality throughout the Walla Walla population?

Performance metrics: Quantity, quality, and utilization of essential fish habitat.

Approach: The Walla Walla Subbasin Plan identifies a set of desired future conditions that may increase natural production and harvest opportunities in the Walla Walla subbasin through habitat restoration and protection, flow augmentation, passage restoration, and hatchery supplementation. There are a number of habitat-based RM&E information needs that must be addressed if the benefits of these management actions are to be effectively detected with sufficient power. For example, the availability and distribution of quality essential fish habitat will be used to define the sampling universe of juvenile and spawner surveys. The adequacy of habitat representation in EDT will need to be evaluated. The condition and importance of several EDT habitat variables, especially bedscour and sediment load, need to be investigated.

Analysis: Spatial and numerical relationships among the habitat and salmonid variables will be used to estimate the degradation or restoration through time of essential fish habitat associated with both natural and anthropogenic disturbance; to estimate the absolute

abundance and distribution of juveniles and spawners using geostatistical expansions; to estimate the effectiveness of habitat restoration and flow augmentation projects; and, to estimate the quantitative relationship between habitat and production. Physical, biological, chemical and ecological habitat conditions will be monitored throughout the subbasin using a variety of techniques.

Status: Not funded, not implemented.

Objective 6: Identify and assess factors limiting production of Walla Walla River steelhead.

Limiting factor analysis is the process by which impairments to population viability are determined. As conditions are improved through management actions, and population limiting factors and threats are influenced, it is essential to re-assess limiting factors to guide future actions. Section 8 of this plan has a detailed limiting factors assessment. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What environmental factors limit steelhead viability in the Walla Walla population?

Approach: Limiting factors and the capacity of the Walla Walla subbasin will be analyzed every five years as part of regular evaluation activities. A multi-species spatially explicit model of the Walla Walla subbasin, such as the ICTRT matrix model and EDT-AHA, will be used to analyze life stage specific survival in Walla Walla, Columbia, and marine life-history stages.

Analysis: Analyses will be conducted with EDT-AHA and ICTRT matrix models.

Status: Not funded.

Objective 7: Assess the impact of habitat improvement and protection on steelhead viability in the Walla Walla subbasin.

Considerable resources are invested in habitat improvement measures. Most habitat improvement projects conduct some monitoring and evaluation at the project scale to determine successful project implementation. However, typically only the cumulative impacts of watershed restoration can be directly linked to increased steelhead production. The connection between Tier 1 habitat project implementation monitoring and Tier 2 effectiveness monitoring must be addressed across the spatial hierarchy of reaches and watersheds. This is a high priority objective. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring Questions:

- Status & Trend Monitoring—What is the current status and trend of steelhead habitat?

- Implementation and Compliance Monitoring—Has the management action been implemented in the prescribed manner and achieved its objectives?
- Effectiveness Monitoring—Has the management action significantly influenced the viability of the Walla Walla River steelhead population?

Performance metrics: Habitat conditions, egg, fry, juvenile, and smolt production and survival, and smolts-per-spawner or per female. Comparison with information on survivals and smolts-per-spawner with other subbasins.

Approach: Status and trend monitoring at the subbasin and population scales is best conducted by using a spatially explicit sampling approach, such as the EMAP approach. Measured habitat variables will be the same as previously described for the John Day populations. Remote sensing (e.g. TIR; LIDAR; and spatially referenced color imagery) is also appropriate and typically addresses spatial scales at watershed or larger landscapes.

Compliance monitoring of restoration projects incorporates record keeping and reporting of activities. Compliance monitoring will be primarily conducted by the implementing entities and will include any parameters identified in related work statements.

Effectiveness monitoring can be approached at the watershed or project spatial scales, and should preferably be directed at measures of abundance, survival, growth, etc. of steelhead or abiotic or biotic factors limiting their recovery. A BACI design (including spatial replication) is recommended for measuring the effectiveness of active restoration activities (Jones & Tonn 2004). For passive restoration activities, a BACI design that monitors trends through time may be appropriate. If comparisons are made to reference or control sites, they should be under similar environmental conditions experienced by the treatment site but outside the influence of treatment activities. Restoration implementing entities must coordinate with monitoring groups prior to action implementation—preferably several years in advance to allow measurement of pre-manipulation variables. Temporal scales must account for timelags related to life history and life cycle. Derived variables include proportion of population-level parameter (e.g. abundance, production, survival) influenced by restoration activity.

Analysis: If at the appropriate scale, direct comparisons of measured parameters with recovery criteria can be made. Otherwise, measures at smaller scales will need to be combined to determine if they have the desired responses at the population level.

Status: Evaluation is partially funded; habitat monitoring is not funded and not implemented. Some projects currently conduct compliance monitoring; however, there is no ongoing effort to aggregate results at the population scale.

Objective 8: Determine the effect of disease and predation on the abundance, productivity, diversity, and distribution of the natural-origin population.

This objective is moderate priority.

Type of monitoring effort: Uncertainties research.

Monitoring questions:

- What is the prevalence of whirling disease in the Walla Walla subbasin and what is its influence on the natural steelhead populations?
- What is the predation rate and predatory impact of introduced fishes in the Walla Walla subbasin on juvenile steelhead?
- What is the effect of predation from piscine predators in the Columbia River migration corridor on juvenile steelhead originating from the Walla Walla subbasin?
- What is the effect of predation from avian predators in the Columbia River migration corridor on juvenile steelhead originating from the Walla Walla subbasin?

Approach: The current distribution and influence of whirling disease on wild steelhead populations is not fully understood. Representative sentinel stations could be established and monitored through time for each population to measure prevalence and intensity of infection rates of whirling disease. Infection, or the presence of *Myxobolus cerebralis* DNA, is detected by PCR analysis. A small incomplete survey was conducted in the late 1980's and a more complete survey is needed.

Collections of smallmouth bass and other potential predators in the WallaWalla River could be conducted using angling techniques. Collected stomach samples are analyzed for the presence of juvenile salmonids. These data could be incorporated into a bioenergetics model to derive a population-level consumption estimate imposed by introduced fishes. Sampling of predatory fish diets should occur during times and locations when and where their distribution overlaps with juvenile steelhead. Interpretation of the predatory impact in the migration corridor should be conducted from methods established in published literature (Ward et al. 1995; Fritts and Pearsons 2006).

To evaluate avian predation, colonies are monitored for presence of PIT tags originating from specific populations (Collis et al. 2001). Bioenergetics models are then used to expand tag recoveries at colonies to population-level impacts (Antolos et al. 2005).

Analysis: The proportion of total mortality attributable to predatory mortality could be estimated from bioenergetics modeling results.

Status: The whirling disease foundation, whirling disease initiative, and Oregon Sea Grant are potential funding sources for whirling disease investigations. Investigations of predation in the migration corridor have been conducted by many agencies with various funding sources including BPA and USACE. This work should continue to effectively evaluate the benefits of the proposed actions.

Objective 9: Determine the effect of mainstem hydropower operations and operational improvements on viability of the Walla Walla River steelhead population.

See John Day MPG for *Timeline, Monitoring questions, and Approach*.

Status: Specific estimates for Walla Walla population are unfunded.

Objective 10: Monitor straying of adult steelhead from the Walla Walla subbasin hatchery programs.

Adult trapping provides substantial data annually on stray fish entering the upper Walla Walla River. Currently, natural spawners in the Walla Walla River include returns originating from naturally spawning adults and from out-of-DPS strays which originate from Lyons Ferry Hatchery releases in the lower Walla Walla River. Hatchery strays were removed at Nursery Bridge Dam by trapping until 1999. Trapping was discontinued after 1999 and replaced with video monitoring. Hatchery fish currently pass above Nursery Bridge Dam to spawn naturally. Continuation of monitoring is needed to assess the annual hatchery fraction and to determine if management changes result in increases or decreases in the hatchery fraction. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring question:

- What is the number and proportion of hatchery fish in the Walla Walla population?

Performance metrics: Number of hatchery fish and proportion of hatchery fish that spawn naturally in the Walla Walla population; percent of Lyons Ferry Hatchery releases that stray

Approach: WDFW monitors the return of summer steelhead throughout southeast Washington through adult trapping (Tucannon River, Lyons Ferry Hatchery, Lower Granite Reservoir, Touchet River, Cottonwood Creek), and spawning ground and creel surveys (sport harvest and CWT expansions can be used to estimate the number that would have returned to the project area)—all of which provide CWT recoveries of marked fish for evaluation purposes. Trapped and/or spawned broodstock fish and carcasses provide data concerning origin, stray rates, sex ratios, age composition, and mean fecundity of each year's run. Spawning ground surveys in Mill Creek provide numbers of redds, spawn timing, and distribution of fish. These surveys provide some measure of the presence of hatchery strays on spawning grounds by noting the presence of fin clips on spawners. This technique has shown some success on the surveys conducted on the John Day River subbasin. A more complete census of natural- and hatchery-origin spawners could be conducted using a weir and trap similar to that previously conducted at Nursery Bridge Dam.

Analysis: Estimating the proportion of out-of-basin strays is a simple comparison of the number of marked and unmarked spawners and carcasses observed within and outside of targeted areas for hatchery returns.

Status: Partially funded, modify and enhance existing monitoring.

Objective 11: Monitor and assess the effect of flow on the availability of spawning and rearing habitat in the mainstem Walla Walla.

Considerable effort and resources are directed at flow restoration in the Walla Walla. However, some of the direct benefits to fish have not been quantified. The relationship between flow restoration and trap-and-haul work is comparatively straightforward: proper flow through

structures and reaches allows for easy passage and a reduction in the need to trap and haul fish. However, the relationship between increased flow and increased spawning and rearing habitat has rarely been directly studied. The IFIM was used to study optimal flow conditions for a number of reaches in the Walla Walla subbasin, and these results are currently being used to guide flow restoration programs. Baseline effectiveness monitoring is needed to understand the added benefits to fish that these future flow programs would bring to the subbasin, and to determine the accuracy of IFIM in predicting habitat use under various flow conditions for priority reaches. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring, uncertainties research.

Monitoring questions:
- What is the effect of flow on the availability of spawning and rearing habitat in the mainstem Walla Walla?
- Are flows suitable for spawning and rearing of steelhead for each reach?

Performance metrics: Spawning and rearing habitat utilization, effectiveness of flow restoration programs.

Approach: Juvenile habitat utilization will be monitored in the Walla Walla mainstem during annual juvenile fish surveys by the CTUIR. Flow will be monitored in these mainstem reaches during fish surveys using a handheld flow meter. Habitat potential will be modeled using a spatially explicit model of habitat quality and quantity such as IFIM or life-cycle analysis, facilitating the evaluation of the relative impacts of various flow management regimes, including the implementation of flow exchange programs and climatological variability.

Analysis: The results of IFIM studies will be compared with results obtained in the field to evaluate the accuracy of the modeled flow recommendations and suggest changes when necessary.

Status: Partially funded, partially implemented.

Objectives 12: Develop models for pre-season estimation of Walla Walla River returns to facilitate management of subbasin fisheries.

Accurate run size predictions allow managers and program staff to plan appropriate broodstock collection, harvest, spawning escapement, and CWT recovery strategies in advance. In addition, models describing return timing can be used in the evaluation of flow management regimes in-season. These models are relatively simple to develop, but require datasets that cover several years or even many decades to be relatively accurate. In general the results of much of the long-term monitoring work will be used to produce these models. This is a low priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What is the annual estimated run size of summer steelhead to the Walla Walla River mouth?
- Can the run size of steelhead be estimated accurately prior to adult returns, and how can the predictor be improved?

Performance metrics: Run size forecast.

Approach: Correlation models have been developed for preseason prediction of steelhead run size to the Columbia River. Local models must be constructed to predict the timing and size of anadromous runs to the Walla Walla. A variety of metrics (including marine conditions, flow conditions, outmigrant abundance, etc.) are collected as part of regular status and trend monitoring or out-of-basin monitoring. These variables can be used to develop run predictors for all steelhead. Detailed methods for this exercise are under development, and are not discussed below.

Analysis: We use multivariate regression analyses to develop predictive models.

Status: Funded, ongoing.

Objective 13: Quantify fishing effort, catch, and harvest for tribal and non-tribal fisheries in the Walla Walla River.

Much of the impetus for the Walla Walla supplementation and reintroduction programs and the WDFW sponsored steelhead hatchery programs is tribal and non-tribal harvest mitigation. Creel or catch-card data are needed to provide information to determine whether steelhead harvest goals are achieved or exceeded, to enumerate fish removed from the run, and to assess how to optimize fishing opportunities through adaptive management. A properly designed creel survey can also provide data for determining the impact of fisheries on the natural-origin fish. This is a moderate priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What are the fishing effort, catch, and harvest by gear type, and location for tribal and non-tribal fisheries in the Walla Walla River?
- What is the annual fishing mortality rate that occurs within the Walla Walla River subbasin?

Performance metrics: Fisher hours, catch, and harvest.

Approach: WDFW utilizes catch cards and a limited creel to monitor harvest. The need to expand these efforts is currently being investigated. Tribal harvest appears minimal and is currently not being monitored.

Analysis: Statistical analyses of creel survey information.

Status: Partly funded; modify and enhance existing monitoring.

13.4 Cascades Eastern Slope Tributaries MPG

The Cascades Eastern Slope Tributaries MPG includes seven steelhead populations in both Oregon and Washington. In Oregon, the populations are the Fifteenmile Creek, Deschutes West, Deschutes East, and the extirpated Crooked River (Deschutes River subbasin) populations. The MPG is unique in a number of ways compared to the others of the Mid-C steelhead DPS. It includes the uppermost expression of an adult winter-run life history (Fifteenmile Creek) in the Columbia River Basin. Impacts to survival of adult winter run steelhead can be expected to differ from the summer run fish during upstream migration through different hydro conditions and fisheries. Smolts from all populations in this MPG migrate through shorter reaches of the Columbia hydrosystem and pass fewer dams. Portions, or all, of the spawning habitat of the three populations in the Deschutes River subbasin have been blocked by hydroelectric development in the subbasin. The sampling methods used to obtain some of the VSP information for this MPG that was used in the recovery plan's viability analyses (see Section 6) are more varied and the management entities that conduct monitoring are diverse.

The most systematic population-level monitoring in the Oregon portion of the Cascades Eastern Slope Tributaries MPG has been through spawning ground surveys conducted by CTWSRO, ODFW, and USFS. This information was used to develop spawner abundance estimates for each population. These surveys had neither been conducted explicitly to represent the spatial distribution of the populations as defined by the ICTRT nor to collect the types of information ideally used to assess each population's viability and to compare current status to the desired population recovery criteria. Nonetheless, the current monitoring routines represent the foundation on which to build future status and trends monitoring that will fill information gaps identified in the viability analyses, allow future changes in VSP criteria to be tracked, and in some cases, function in part as action effectiveness monitoring. Monitoring infrastructure currently exists or has been deployed in the past in the MPG that could inform future VSP status and trend assessments including the following:

- Abundance of adult progeny on the spawning grounds (for productivity expressed as recruits-per-spawner ratios)
- Trends in abundance of juveniles and SARs
- Spatial distribution of spawners
- Diversity of life history characteristics of both adults and juveniles including differences, similarities, or changes in genetic traits

This plan describes and supplements the existing monitoring activities so that the status and trend of the steelhead populations can be compared with recovery criteria. It is not exhaustive, but generally builds on the strengths of existing monitoring efforts that could be used to update the viability assessments that were conducted and adapt existing efforts to fill missing information. A balance between an ideal monitoring effort and what is sufficient relative to costs and resources is considered. Wherever possible, attempts to integrate status and trends monitoring with action effectiveness monitoring are made.

Critical Uncertainties

Critical uncertainties for the population group that currently limit the ability to make informed management decisions have been identified by local area managers. We combined these uncertainties with those identified during the recovery planning process to produce the RM&E objectives that are addressed herein by our recommended M&E efforts. Not all objectives are associated with each population segment. For example, there is no within-basin harvest for the Fifteenmile Creek population. The objectives include:

1. Determine the current status and trend in the abundance and productivity of natural-origin spawners and compare to viability abundance criteria for each population.
2. Determine the status of the spatial structure of each population based on current and historically utilized habitat.
3. Determine the effects of out-of-basin strays on the productivity of each population relative to viability criteria.
4. Determine the status and trend in conditions of current and historically utilized habitat within each population.
5. Determine the freshwater productivity of each population relative to viability criteria and identify primary habitat factors limiting freshwater production.
6. Determine the effects of disease and predation on the abundance, productivity, diversity and spatial structure of the natural populations.
7. Determine the effect of hydropower on the abundance, productivity, diversity and distribution of the natural populations.
8. Determine what effects habitat degradation and habitat restoration actions have on the abundance, productivity, and spatial structure of the natural populations.
9. Determine the influence of in-basin harvest on the abundance and productivity of natural-origin spawners.

13.4.1 Fifteenmile Creek Population

Objective 1: Determine the status and trend in the abundance of natural-origin spawners relative to viability abundance levels.

The status of a population is determined by estimating the VSP parameters described in the recovery plan. The VSP parameters include adult abundance, population productivity or growth rate, population spatial structure, and diversity. This is a highest priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- Is the 10-year GM of natural-origin steelhead spawners in the Fifteenmile Creek subbasin greater than or equal to the recovery criterion for natural spawners?
- What are the current spawner abundance and five-year trend in abundance?
- What are the current and trend in the 20-year population growth rate?
- What are the current and trend in recruits/spawner compared to the recovery goal?

Performance Metrics: Spawner abundance, recruits/spawner.

Approach: Currently, abundance of adult spawners in the Fifteenmile Creek system is estimated based on observations of redds from three-pass spawning ground surveys conducted annually within each MaSA. The present sampling is statistically representative of spawning activity allowing inference to the total Fifteenmile Creek spawning population and allows annual monitoring of the distribution of spawners in each of the population's MaSAs. The sample design is a stratified random survey where each MaSA is divided into five-mile sections that cover the currently known spawning habitat. A one-mile reach is randomly selected each year from the five one-mile sections in each five-mile stratum and surveyed by foot once per week three times during spring.

Analysis: The total season's abundance of redds is estimated by summing individual redds observed in each five-mile section and expanding by the surveyed/unsurveyed proportion (approximately five-fold). A fish/redd ratio is presently estimated by counting spawners passed above a weir (outside of the DPS) and results of subsequent multiple complete area census spawning ground redd surveys.

To estimate abundance of progeny (spawning recruits), age structure is assumed to be similar to wild winter steelhead in the downstream Hood River.

Status: Currently implemented.

Objective 2: Determine the status of the spatial structure of the population based on current and historically utilized habitat.

Spatial and seasonal distribution of juveniles, their habitat use, and density within the MaSAs and MiSAs, particularly in Mill and Chenoweth creeks, are not presently well known. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What is the spatial distribution of the occupied spawning areas within the population boundaries?
- What is the current spatial extent and distribution of rearing habitat used by juvenile steelhead?

Approach: An EMAP sampling approach of all known spawning and rearing areas could be used to refine the known spatial distribution of both adult and juvenile steelhead for the Fifteenmile Creek population. Representative sites within the watershed would be sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. All observed adult spawners and redds would be geographically referenced using handheld GPS units for inclusion in a GIS. Juvenile steelhead would be sampled using snorkeling or electrofishing techniques. This approach would refine current knowledge of steelhead spatial distribution for this population segment.

Analysis: Data would be analyzed as distribution data in a GIS format. The known distribution of steelhead will be modified when previously unknown blockages to migration or newly inhabited reaches are observed. Juvenile steelhead densities are determined in each study reach.

Status: Not currently implemented.

Objective 3: Determine the abundance of out-of-basin strays in the Fifteenmile Creek population relative to viability criteria.

The proportion of spawning steelhead in Fifteenmile Creek that are hatchery-origin fish is assumed to be very low, but is not known. To monitor the presence of hatchery-origin fish, additional effort during spawning ground surveys will be necessary to observe sufficient numbers of fish to develop annual estimates of hatchery fraction and hatchery fish abundance. This is a high level priority.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What proportion of steelhead spawners in the Fifteenmile Creek population is derived from out-of-basin hatchery stocks?
- What is the origin of out-of-basin strays?
- What is the population-level genetic composition of the Fifteenmile Creek population?

Approach: The Fifteenmile Creek basin lacks facilities to capture adult steelhead. Determination of out-of-basin strays will therefore rely on identification of hatchery-marked adults observed on spawning ground surveys, and from incidental catches. To determine population-level genetic composition, genetic data that allow an objective determination of the population(s) structure are required. Age-0 *O. mykiss* from several representative streams in the population segment are currently sampled annually. Collection of juveniles from a minimum of four cohorts will be sampled. The population will be characterized using a suite of nuclear DNA markers, including both microsatellite loci (variable-number simple-sequence repeats) and non-coding SNPs, or base substitutions assayed via restriction enzyme analysis (Moran et al. 1997). The current monitoring program is conducted as part of the Columbia Basin-wide steelhead genetics monitoring.

Analysis: Estimating the proportion of out-of-basin strays is a simple comparison of the number of marked and unmarked spawners and carcasses observed. Direct comparisons can then be made with recovery criteria. DNA tissue samples are analyzed by NMFS using known microsatellite markers. Microsatellite loci are analyzed using pairwise FST comparisons to estimate levels of gene flow and to identify geographic areas that contain genetically differentiated populations.

Status: Spawning ground surveys are implemented and coordinated. Genetics analysis is implemented and coordinated collaboratively between ODFW and NMFS Northwest Science Center. Federal funds (NMFS) are used for genetics stock analysis.

Objective 4: Determine the status and trend of current and historically utilized habitat.

This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What are the status and trend in habitat quantity and quality throughout the population area?

Approach: The same EMAP sampling approach of all known spawning and rearing areas, as described above is recommended for sampling the known spatial extent and status and trend of steelhead habitat. Habitat variables would be monitored as defined by ODFW Aquatic Inventories design (Moore et al. 2002) and are measured at the unit and reach scale.

Analysis: This type of data are analyzed as distribution data in a GIS format. Database and GIS formatting of data allow associations with land use, land vegetation coverage, and many other attributes at the population and smaller scales.

Status: Not implemented.

Objective 5: Determine the freshwater productivity of the population relative to viability abundance levels and identify primary factors limiting freshwater production.

Trapping juvenile outmigrants will help provide estimates of smolt production for the watershed, allow estimation of smolt-to-adult survival rates, and provide life history diversity information including timing, age, size, and genetic variation. This expanded monitoring effort will allow for assessment of the cumulative benefits of the habitat protection, enhancement, and restoration actions on juvenile survival and abundance in the Fifteenmile Creek population.

The Fifteenmile Creek subbasin plan identifies an "ideal" monitoring scenario where returning adults would be trapped and enumerated and a juvenile outmigrant trap would be operated near the mouth of Fifteenmile Creek. This scenario could represent a second tier to more comprehensively monitor the population. Its benefits would need to be weighed against the implementation costs. This is a highest level priority.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What are the current and trend in freshwater productivity measured as smolts/redd?
- What is/are the primary factor(s) limiting freshwater production of steelhead?

Approach: The ratio of smolts/adult is the principle measure of freshwater productivity. Smolt abundance will be determined using traps. If we do not obtain adequate funding for a weir to count adults, then redd counts will be used. Freshwater productivity will be assessed as smolts/redd or smolts/adult. Trapping with RSTs and mark-recapture will be used to

estimate smolt abundance. Egg-to-smolt survival requires an estimate of the number of eggs deposited by individual females or deposited in each redd. Parr-to-smolt survival will be estimated by capturing a representative number of parr in their rearing habitat, PIT tagging them, and then monitoring their recapture at the downstream smolt traps. Migration survival can similarly be estimated by monitoring detections of PIT-tagged individuals as they pass through PIT tag detection facilities.

Analysis: Smolt abundance will be estimated using mark/recapture techniques (Thedinga 1994; Steinhorst 2004). Survival and productivity measures are simple proportions and ratios from one life stage to another.

Status: Operation of smolt and adult traps are not currently implemented.

Objective 6: Determine the effect of disease and predation on the abundance, productivity, diversity, and distribution of the natural-origin population.

This is a moderate priority objective.

Type of monitoring effort: Long-term status and trend monitoring and short-term research.

Monitoring questions:

- What is the prevalence of disease in the basin and what is its influence on the natural steelhead populations?
- What is the effect of predation from piscine predators in the Columbia River migration corridor on juvenile steelhead originating from Fifteenmile Creek?
- What is the effect of predation from avian predators in the Columbia River migration corridor on juvenile steelhead originating from Fifteenmile Creek?

Approach: The current distribution and influence of whirling disease on natural steelhead populations is not fully understood. Representative sentinel stations would be established and monitored through time for this population to measure prevalence and intensity of infection rates of whirling disease. Infection, or the presence of *Myxobolus cerebralis* DNA, is detected by PCR analysis.

To evaluate avian predation, colonies are monitored for presence of PIT tags originating from specific populations (Collis et al. 2001). Bioenergetics models are used to expand tag recoveries at colonies to population-level impacts (Antolos et al. 2005). This method requires the collection and PIT tagging of smolts originating from the Fifteenmile Creek population. The piscine and avian predation monitoring is outside the scope of this RM&E plan. However, we encourage the ongoing monitoring programs to continue their efforts to address these limiting factors and threats.

Analysis: The proportion of total mortality (e.g., SAR) attributable to predatory mortality could be estimated from bioenergetics modeling results. Infection rates of sentinel fish from disease would need to be related to actual mortality rates experienced in the natural population. If this were determined then mortality rates resulting from disease could be

estimated as a proportion of freshwater mortality (i.e., egg to smolt mortality) although some delayed mortality may also occur (Sollid et al. 2004).

Status: Not implemented at the population level.

Objective 7: Determine the effect of hydropower on the abundance, productivity, diversity, and distribution of the Fifteenmile Creek population.

This is a moderate priority objective because the population resides above only one dam.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What is the effect of Columbia River hydropower operations on Fifteenmile Creek steelhead smolts?
- What is the effect of Columbia River hydropower operation on returning Fifteenmile Creek adult steelhead originating from Fifteenmile Creek?

Approach: PIT tags have been used successfully to measure the influence of hydropower operations on migrating salmonids (Berggren et al. 2006; Schaller et al. 2007). PIT-tagged fish are monitored for detections at FCRPS facilities along the migration corridor at both juvenile and adult life stages using DART and PTAGIS databases. Detection probabilities of juvenile salmonids migrating downstream at FCRPS facilities are modeled using the SURPH analytical tool (Lady et al. 2003). Adult detection (purportedly 100%) is currently available at ladders on several dams including Bonneville, and is expected in the near future at The Dalles.

Analysis: Juvenile survivals at each FCRPS facility can be estimated using the SURPH model. Adult survival between facilities will soon be possible by comparing detections at adult ladder facilities along the migration corridor. Rates can be expanded to population-level impacts using the relative number of fish PIT tagged and abundance estimates generated from mark-recapture at RSTs.

Status: This method would require the collection and PIT tagging of smolts originating from the Fifteenmile Creek population. Systematic PIT tagging of juveniles in Fifteenmile Creek is not implemented.

Objective 8: Determine the effect of habitat degradation and habitat restoration activities on the abundance, productivity, and distribution of the Fifteenmile Creek population.

This is a highest priority objective.

Type of monitoring effort: Long-term status & trend monitoring, implementation and compliance monitoring, and effectiveness monitoring.

Monitoring questions:

- Status & Trend Monitoring—What are the current status and trend of steelhead habitat?
- Implementation and Compliance Monitoring—Has the management action been implemented in the prescribed manner and achieved its objectives?
- Effectiveness Monitoring—Have the management actions significantly influenced the viability of the Fifteenmile Creek steelhead population?

Approach: Status and trend monitoring at the subbasin and population scale are best conducted by using a spatially explicit sampling approach, such as the EMAP approach developed by the EPA. Measured habitat variables will be the same as previously described for the John Day populations. Remote sensing (e.g., TIR imagery, LIDAR, and spatially referenced color imagery) is also appropriate and typically addresses spatial scales at watershed or larger landscapes.

Compliance monitoring of restoration projects incorporates record keeping and reporting of activities. Compliance monitoring will be primarily conducted by the implementing entity and will include parameters identified in related work statements. Effectiveness monitoring can be approached at the watershed or project spatial scales. IMWs are one example of the watershed approach. Effectiveness monitoring should preferably be directed at measures of abundance, survival, growth, etc. of steelhead or abiotic or biotic factors limiting their recovery. A modified BACI (Smith 2002) design (including spatial replication) is recommended for measuring the effectiveness of active restoration activities (Jones & Tonn 2004). For passive restoration activities, a BACI design that monitors trends through time may be appropriate. If comparisons are made to reference or control sites, they should be under similar environmental conditions experienced by the treatment site but outside the influence of treatment activities. Restoration implementing entities must coordinate with monitoring groups prior to action implementation—preferably several years in advance to allow measurement of pre-manipulation variables. Temporal scales must account for timelags related to life history and life cycle.

Analysis: If collected at the appropriate scale, direct comparisons of measured parameters with recovery criteria can be made. Otherwise, measures at smaller scales would need to be scaled up to determine if they would have desired responses at the population level.

Status: Implementation monitoring is currently conducted by the groups that implement restoration activities.

Objective 9: Determine the effect of in-basin harvest on the abundance, productivity, and diversity of the Fifteenmile Creek population.

Under current fisheries regulations, adult steelhead cannot be legally retained in any of the minor Columbia River tributaries (Fifteenmile, Mill or Chenoweth creeks). Further, Fifteenmile Creek is closed to all recreational winter steelhead fishing, including catch and release. The Fifteenmile Creek population is subject to target and incidental fishery impacts in sport, commercial, and tribal fisheries occurring in the mainstem of the lower Columbia River and in Bonneville Reservoir. Passage rates of winter steelhead through mainstem fisheries, past the dams, and through the reservoirs are not known with any certainty at a population level. Run

timing of Bonneville Reservoir and upstream summer steelhead populations can overlap with winter run populations. This is a moderate priority objective.

Type of monitoring effort: Long term status and trends

Monitoring questions:

- What is the stock composition of adult steelhead populations in the mainstem Columbia River during winter and early spring?
- What is the annual fishing mortality rate that occurs outside of the Fifteenmile Creek subbasin?

Approach: Passive monitoring of representatively PIT-tagged steelhead ascending Bonneville Dam and The Dalles Dam will help monitor run timing and stock composition. Enhanced stock composition monitoring using GSI methods will also add valuable information. Enhancing catch sampling in the fisheries will aid in partitioning harvest rates among mixed-DPS and MPG populations across the winter and early spring seasons.

Analysis: See Objective 8.

Status: Not implemented at the population level.

13.4.2 Eastside and Westside Deschutes River Populations

Major spawning areas of two populations, Deschutes River Eastside and Deschutes River Westside, are routinely monitored for abundance and spatial distribution of spawning adults (redd counts from spawning ground surveys). Abundance of steelhead in the Westside MaSAs in the Warm Springs River is determined based on a count at the Warm Springs NFH barrier. The extirpated Crooked River population is not addressed in this RM&E plan; however, monitoring was previously discussed in Section 9. Both extant populations use the mainstem of the Deschutes River for spawning and rearing, and the area delineation separating the two is the mainstem Deschutes River near the mouth of Trout Creek. Portions of both populations' historical range are blocked by the Pelton-Round Butte Complex. Round Butte Hatchery produces a Deschutes-origin hatchery stock of steelhead to mitigate for the blocked habitat. Recent FERC hydropower re-licensing negotiations have resulted in the beginning of an effort to restore steelhead upstream of Round Butte Dam focusing particularly on Whychus Creek. Significant numbers of hatchery steelhead from outside the subbasin enter the Deschutes River annually and some are known to remain within the Deschutes and its tributaries to spawn, but the actual rate or numbers are not known with certainty. The Deschutes River and its tributaries (particularly those of the Deschutes Westside steelhead population) support large numbers of resident redband trout (*O. mykiss*), and a blue ribbon trout fishery is a major attraction to the Deschutes River.

These subbasin characteristics present unique challenges to monitoring the VSP parameters for each of the two steelhead populations. The monitoring activities which provided the data used to assess the viability of each population (see Appendix B) are described briefly below, including recommended improvements needed for better status and trends monitoring of viability

parameters specific to each population. Because steelhead status and trend monitoring in the subbasin is so interrelated with gaining insight to critical uncertainties and tracking the effectiveness of major recovery actions, this monitoring overview addresses population status and trend monitoring, action effectiveness monitoring, and critical uncertainties research in combination. The main monitoring issues identified in order of priority by local fisheries managers include:

1. Straying: What is the cause and origin of strays in the Deschutes? Has introgression with strays impacted the genetic characteristics of natural-origin steelhead in the Deschutes? How many strays are overwintering in the Deschutes, entering spawning tributaries, spawning in the main stem Deschutes, and what are the effects on fitness? What is the fall back rate for non-Deschutes hatchery and natural fish that pass above Sherars Falls?
2. Population structure of Eastside vs. Westside: Is their a difference in the two populations and the stock-recruit function?
3. Reintroduction: Which stocks should be used as broodstock (Eastside vs. Westside)? What would be the effects on the founding population? What will the effect of competition of juvenile *O. nerka* and *O. mykiss* be? If sockeye are successful in the reintroduction, what will be the effect of large numbers of juvenile sockeye in the lower Deschutes? How successful will the steelhead reintroduction be?
4. Resident *vs.* anadromous: What is the relationship between the two, causative mechanism for either life history, and is competition an issue? What influence does the abundant resident population have on the steelhead populations?

Objective 1: Determine the status and trend in the abundance of natural-origin spawners and compare to viability abundance criteria for the Deschutes River populations.

The critical uncertainties in characterizing the abundance of each spawning population and abundance of adult progeny (recruits) returning to spawn to estimate abundance and productivity (spawner to spawner ratio) are threefold:

1. The unknown abundance of fish that spawn in the mainstem Deschutes River and their relative contribution to the Westside and Eastside populations.
2. The abundance and origin of hatchery steelhead that spawn naturally and the inability to enumerate adult progeny and assess the degree of risk from out-of-MPG hatchery spawners.
3. Annual population-specific information on freshwater and saltwater adult age at return is unavailable to partition natural-origin spawners into broodyear of origin.

Presently, all of the major spawning areas of the two populations in the Deschutes River are surveyed annually for presence of steelhead adults and redds with varying degrees of spatial coverage. In addition, adult weirs are fished on most major spawning tributaries. Observations from these surveys and weir counts are used to estimate the abundance of redds in each major spawning area and to characterize the degree of occupancy (spatial distribution). These surveys are neither statistically designed nor conducted systematically and inferences are made to unsurveyed areas. This approach has weaknesses because there is no validation of the

relationship of spawner density in surveyed and unsurveyed areas. Modifying the present spawning ground surveys is needed to assure observations of redds are statistically based.

Alternatively, a stratified random spawning ground survey similar to that used in the Fifteenmile Creek subbasin could be conducted in the MaSAs of Buckhollow, Bakeoven, Trout, and Shitike creeks. If the present surveys are changed, appropriate fixed sites could be maintained to allow for calibrating historical data, and allow flexibility for local project-level action effectiveness monitoring such as for habitat improvement actions. Intensity of present single pass spawning ground survey effort could possibly be redistributed to multiple passes over a smaller proportion of the spawning area than is presently surveyed. To monitor spawning activity in the mainstem of the Deschutes River, spawning ground surveys would need to be conducted either by air or boat. To date, only two single pass aerial surveys of spawning steelhead have been conducted. This is a highest level priority.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- Is the 10-year GM of natural-origin steelhead spawners in the Westside and Eastside populations greater than or equal to the recovery criterion for natural spawners?
- What are the current spawner abundance and five-year trend in abundance?
- What are the current and trend in the 20-year population growth rate?
- What are the current and trend in recruits/spawner compared to the recovery goal?

Performance metrics: Spawner abundance, recruits/spawner.

Approach: Where weirs are absent, redd surveys are the only alternative to estimate annual adult abundance for recruit/spawner and trend analyses. The recommended survey design is a spatially balanced site selection and a rotating panel design for temporal selection (EMAP approach; Stevens and Olsen 2004). Ideally, sampling using this design would also be conducted at the population scale which would require a separate sample draw and additional samples. Redd count surveys would be conducted by walking and/or floating all streams within the index (one-time annual counts) and randomly selected reaches (bi-weekly counts, $\geq$ 3 counts/year).
Analysis: Estimate the number of naturally produced spawners using proportions of observed naturally produced fish (unmarked) and hatchery (fin clipped) fish, total number of redds, expansion factor of surveyed stream length/available stream length, and fish/redd ratio. Calculate 10-yr GM for abundance of naturally produced fish. Calculate recruits/spawner based on redd counts and estimated spawner age structure. Analyze as a time series (trend analysis).

Status: State of Oregon funds index spawning ground surveys. An EMAP approach for spawning ground surveys has been previously proposed by ODFW and approved by the ISRP and NPCC, but BPA failed to fund the proposed monitoring.

Objective 2: Determine the status of the spatial structure of each population based on current and historically utilized habitat.

This is a highest level priority.

Type of monitoring effort: Long term status and trend monitoring

Monitoring questions:

- What is the spatial distribution of the occupied spawning areas within the population boundaries?
- What is the current spatial extent and distribution of rearing habitat used by juvenile steelhead?

Approach: The same EMAP sampling protocol of all known spawning and rearing areas as used for determining abundance of spawners is recommended for refining the known spatial extent of both adult and juvenile steelhead. Representative sites within the subbasin will be sampled annually using a three-panel rotating panel design. Panels include annual, every four years, and one-time visit selections. All observed adult spawners and redds are geographically referenced using handheld GPS units for inclusion in a GIS. Juvenile steelhead are sampled using snorkeling or electrofishing techniques.

Analysis: Data would be analyzed as distribution data in a GIS format. The known distribution of steelhead is modified when previously unknown blockages to migration are discovered. Juvenile steelhead are evaluated as fish/pool in each study reach.

Status: Not implemented nor funded. The same limitations indicated above in Objective 1 are relevant here.

Objective 3: Determine the effects of out-of-basin strays on the productivity of each population.

Hatchery strays, especially from out-of-subbasin hatcheries, pose a significant threat to wild summer steelhead populations in the Deschutes subbasin. The large influx of out-of-subbasin stray summer steelhead may contribute maladapted genetic characteristics to the wild summer steelhead populations in the Deschutes River subbasin. While Round Butte Hatchery origin summer steelhead contribute to this problem, their abundance is much less and they are genetically more similar than the large number of out-of-subbasin strays. The cumulative effect of this genetic introgression may contribute to reduced productivity of the wild populations.

ODFW completed and submitted a comprehensive study plan to investigate the impact of strays. Implementing ODFW's study plan to investigate the reproductive success of stray hatchery and wild steelhead in the lower Deschutes River would address uncertainties of the magnitude of straying, its actual effect on wild populations in the Deschutes River, as well as provide a tool to exclude hatchery steelhead from either Buckhollow or Bakeoven creeks in the future. Completion of ODFW's study objectives would determine the number of stray hatchery steelhead entering Bakeoven and Buckhollow creeks, degree of introgression between hatchery and natural fish, relative reproductive success, and the influence of hatchery fish on natural productivity.

Improved monitoring of stray hatchery fish in the Deschutes River has regional significance in the Columbia Basin. For example, efforts underway in the Snake River Basin through the Lower Snake River Compensation Plan to decrease and monitor stray rates of Snake River hatchery steelhead will require both knowledge of which fish stray, at what rates, and whether efforts taken to modify stray rates are effective. The management and operation of the FCRPS, specifically barging, may be increasing the rate of straying of salmon and steelhead originating upstream of the Mid-C steelhead DPS. Quantifying this potential effect and monitoring effectiveness of efforts to reduce straying will require continued monitoring of straying into the Deschutes, as well as the ability to identify outmigrating juveniles in the mainstem Columbia and their migration experience (in river or barged). Implementing the Columbia Basin Fish and Wildlife Program's Comparative Survival Study plan for steelhead tagging would contribute significantly to improving information related to straying.

A coalition of Deschutes River fisheries managers has been working together to address a number of population identification issues using genetics techniques. Continuing this effort will greatly help to inform population structure and genetic characteristics of summer steelhead in the Deschutes River subbasin. A recent draft of a project plan outlines the scope of future work (personal communication, D. Hand, USFWS, CRFPO). In FY2002, the U.S. Fish & Wildlife Service obtained funding for part of the Federal Columbia River Power System biological assessments, opinion and hatchery operations. In FY 2004, the Columbia River Fisheries Program Office (CRFPO) secured additional funding for population monitoring. This "add-on" was to lend additional support to on-going monitoring & evaluation projects as well as help answer additional questions associated with hatchery operations and impacts to the Deschutes basin native fish community. On-going evaluations include: 1) population dynamics and genetics of hatchery- and natural-origin spring Chinook salmon in the Warm Springs River and Shitike Creek; 2) evaluating the reproductive success of hatchery spring Chinook salmon outplanted into Shitike Creek; 3) evaluating the ecological interactions between hatchery- and natural-origin fish; and, 4) assessing the population structure of summer steelhead trout in the Deschutes River and potential impact from out-of basin hatchery strays.

Additional unanswered questions were developed by the ICTRT (2003). In identifying independent populations of listed steelhead in the Interior Columbia River Basin, they noted that limited information existed to evaluate genetic differences between steelhead occupying the tributaries on the east and west sides of the lower Deschutes River below the Pelton-Round Butte Dam complex. Concurrently, the Pelton-Round Butte Fish Reintroduction Committee expressed interest in developing a better understanding of steelhead population structure in the lower Deschutes in order to determine the best donor stock for reintroduction above the dam complex. A series of meetings among ODFW, CTWSRO, CRFPO, and the Abernathy Fish Technology Center identified a variety of issues and information needs regarding steelhead in the Deschutes. In response to the various discussions, the CRFPO and the Pelton-Round Butte Fish Reintroduction Committee organized a meeting to bring together all interested parties and identify issues of concern. This group agreed on a set of overall study objectives and drafted a phased implementation approach:

1. Augment existing information to develop an understanding of the population structure and genetic variability among steelhead occupying tributaries and the mainstem Deschutes River downstream of the Pelton-Round Butte Complex;
2. Evaluate the effect of out-of-basin strays on the Deschutes River populations (rate of strays and reproductive contribution of strays); and,
3. Provide information pertinent to brood stock selection that would assist with efforts to reintroduce steelhead to currently inaccessible portions of the middle and upper basin.

As adult fish begin returning from reintroduction efforts upstream of Round Butte Dam, they too will need to be distinguished from the Deschutes RBH stock and the Westside and Eastside wild populations. Studies may need to be implemented to assure the fidelity of these reintroduced fish to their parent stream. A draft reintroduction plan (personal communication, M. Gauvin, CTWSRO) includes key metrics to monitor fish passage above Round Butte Dam and the reintroduction effort. This monitoring should be integrated with monitoring of the other populations including Round Butte Hatchery steelhead, with emphasis on smolt-to-adult return rates, harvest rates (or impacts) in the Deschutes River, counts of returning adults by species and sex at Round Butte Dam, spawn timing and success (redd counts) by species and subbasin; and adult recruits per spawner. This is a highest level priority.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What proportion of steelhead spawners in the Deschutes subbasin are out-of-basin hatchery strays?
- What is the origin of out-of-basin strays?
- What is the population-level genetic composition of the Deschutes populations?

Approach: Presence of hatchery fish by origin is monitored at trapping facilities in the Deschutes subbasin. Steelhead ascending Sherars Falls are sampled routinely and tagged for run-to-the river population abundance estimates. Hatchery-origin fish are captured, removed, and examined for hatchery of origin at Bakeoven, Buckhollow, Trout and Shitike creeks, and at Pelton trap and Warm Springs NFH. Fish can also be examined in creel surveys. All observed fish marked with a fin clip can be sampled for the presence of a coded-wire or PIT tag to determine hatchery origin. Where spawning ground surveys are conducted, the number of marked (adipose fin clip) and unmarked (presumably natural-origin) fish will be visually identified and enumerated. This information is important to monitor the potential magnitude and origin of hatchery straying. The rate at which fish observed at Sherars Fall eventually fall back and leave the Deschutes River system and continue migrating to their parent stream remains unknown. Although funding is not available, there is a need to conduct a radio telemetry project to assess fall back rates.

A number of recent and future actions will allow better monitoring of the magnitude of straying into the Deschutes River and the effectiveness of actions to control stray rates. The Sherars Falls trap is now equipped with PIT tag detection capability and will allow adult detection of both fish PIT-tagged as juveniles and released in the Deschutes River subbasin and those tagged and released outside of the Deschutes. If sufficient numbers of hatchery

summer steelhead were representatively tagged throughout the Columbia Basin, a better understanding of the rate at which out-of-population hatchery fish descend Sherars Falls could be developed. Implementing the Columbia Basin Fish and Wildlife Program's Comparative Survival Study plan for steelhead tagging would contribute to monitoring stray rates in the Deschutes. The recent effort to representatively PIT tag all LSRCP hatchery steelhead will greatly enhance the ability to estimate fall back. Fish that pass above Sherars Falls and are later detected migrating up the Columbia River above the Deschutes will provide better estimates of fall back rates. Repeating Columbia River mainstem radio telemetry studies, with additional effort to track steelhead that enter the Deschutes River further upstream and longer throughout the winter and possibly spring, would help to quantify the stray rate upstream of Sherars Falls.

To determine population-level genetics composition for the MPG, genetics data which allow an objective determination of the population(s) structure are required. Age-0 *O. mykiss* from several representative streams in each population segment have recently been sampled. Collection of juveniles from a minimum number of cohorts (3-4) is recommended using non-lethal fin tissue for DNA analysis. Population genetics will be characterized using a suite of nuclear DNA markers, including both microsatellite loci (variable-number simple-sequence repeats) and non-coding SNPs, or base substitutions assayed via restriction enzyme analysis (Moran et al. 1997).

Analysis: Estimating the proportion of out-of-basin strays is a simple comparison of the number of marked and unmarked spawners observed. Direct comparisons can then be made with recovery criteria. DNA tissue samples are analyzed by USFWS using known microsatellite markers. Microsatellite loci are analyzed using pairwise FST comparisons to estimate levels of gene flow and to identify geographic areas that contain genetically differentiated populations.

Status: Ongoing or planned, but efforts need to be enhanced.

Objective 4: Determine the status and trend in conditions of current and historically utilized habitat for each population.

This is a high level priority.

Type of monitoring effort: Long term status and trend monitoring.

Monitoring questions:

- What is the status and trend in habitat quantity and quality in the Deschutes Eastside and Westside populations?

Approach: Similar to other watersheds, we would use an EMAP sampling protocol as previously described for the John Day populations. Habitat variables follow ODFW Aquatic Inventories design (Moore et al. 2002) and are measured at the unit and reach scale.

Analysis: Data will be analyzed as distribution data in a GIS format. Database and GIS formatting of data allow associations with land use, land vegetation coverage, and many other attributes at watershed and population scales.

Status: Not implemented and currently unfunded.

Objective 5: Determine the freshwater productivity of each population relative to viability criteria and identify primary habitat factors limiting freshwater production.

No quantitative time series of smolts per adult or smolt-to-adult survival rates have been developed to represent Deschutes River populations across multiple generations. This type of information is important to monitor productivity and segregate tributary productivity from the migration and ocean life stages. This metric allows for better understanding of the productive potential of steelhead in the Eastside and Westside populations. Productivity appears to be inherently low in the Westside population relative to other Columbia Basin summer steelhead populations (see Section 7). It is hypothesized that interactions with the abundantly naturally occurring resident *O. mykiss* may limit steelhead production. Presently, juvenile outmigrants are trapped annually in the Warm Springs River and near the mouth of Trout Creek. With a more accurate method of determining spawner abundance in Trout Creek and smolt abundance estimates from the Warm Springs River, an index of smolts/adult or smolts/redd would be available for each population. This is a highest priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:
- What are the current and trend in freshwater productivity measured as smolts/redd?
- What are the primary factors limiting freshwater production of steelhead?

Approach: The ratio of smolts/adult is a recommended measure of freshwater productivity. Smolts are typically counted using traps as they migrate out of their natal habitat. If weirs are not present to count adults, then redd counts can act as a surrogate. Freshwater productivity will be measured as smolts/redd or smolts/adult. Trapping with RSTs is currently being conducted on the Trout Creek tributary. Egg-to-smolt survival requires an estimate of the number of eggs deposited by individual females or deposited in each redd. Parr-to-smolt survival can be estimated by capturing a representative number of parr in their rearing habitat, PIT tagging them, and then monitoring their recapture at the downstream smolt traps. Migration survival can similarly be estimated by monitoring detections of PIT-tagged individuals as they pass through PIT tag detection facilities.

Analysis: Smolt abundance would be estimated using mark/recapture techniques (Thedinga 1994, Steinhorst 2004).

Status: Partially implemented at the tributary level. Current PIT tagging efforts on Trout Creek need to be coordinated with efforts to estimate escapement.

Objective 6: Determine the effect of disease and predation on the abundance, productivity, diversity, and distribution of the Deschutes River populations.

Out-of-subbasin strays also pose a threat to steelhead population health. About 5% of the hatchery stray steelhead have tested positive for whirling disease (Engleking 2002). This is a high level priority.

Type of monitoring effort: Disease is short term research; predation long term status and trends.

Monitoring questions:

- What is the prevalence of whirling disease in the Deschutes subbasin and what is its influence on the natural steelhead populations?
- What is the effect of predation from piscine predators in the Columbia River migration corridor on juvenile steelhead originating from the Deschutes River?
- What is the effect of predation from avian predators in the Columbia River migration corridor on juvenile steelhead originating from the Deschutes River?

Approach: The current distribution and influence of whirling disease on wild steelhead populations is not fully understood. Representative sentinel stations could be established and monitored through time for each population to measure prevalence and intensity of infection rates of whirling disease. Infection, or the presence of *Myxobolus cerebralis* DNA, is detected by PCR analysis. A logical place to locate initial sentinel tests would be in locations where hatchery strays are known to be prevalent because they are a known vector of transmission from infected watersheds in northeast Oregon (Sollid et al. 2004). Sentinel stations should then be placed near the mouths of important tributary and mainstem habitats occupied by fry and parr life history stages of steelhead.

To evaluate avian predation, colonies are monitored for presence of PIT tags originating from specific populations (Collis et al. 2001). Bioenergetics models can then be used to expand tag recoveries at colonies to population-level impacts (Antolos et al. 2005).

Analysis: The SAR attributable to predatory mortality could be estimated from bioenergetics modeling results. Infection rates of sentinel fish from disease would need to be related to actual mortality rates experienced in the natural population. If this were determined then mortality rates resulting from disease could be estimated as a proportion of freshwater mortality (i.e., egg to smolt mortality) although some delayed mortality may also occur (Sollid et al. 2004).

Status: The whirling disease foundation, whirling disease initiative, and Oregon Sea Grant are potential funding sources for whirling disease investigations. Universities, through graduate student projects, are often used for this type of research and monitoring.

Objective 7: Determine the effect of hydropower on the abundance, productivity, diversity, and distribution of the Deschutes River populations.

MPG-specific SARs and migration survival rates need to be developed for the Mid-C steelhead DPS. The Deschutes River subbasin has the infrastructure to contribute PIT-tag groups of natural-origin steelhead to this need. Recently, approximately 1,400 steelhead smolts per year have been PIT tagged and released at the Trout Creek outmigrant trap (personal communication, Tom Nelson, ODFW, Madras). The Columbia Basin Fish and Wildlife Program's Comparative Survival Study plan for PIT-tagging steelhead includes a mark group for the Warm Springs River, but it has not been implemented. Implementing the Warm Springs tagging, and supplementing Eastside PIT-tagging with juveniles from the Buckhollow-Bakeoven hatchery influence study would result in a mark group from both populations that yields statistically robust annual SARs and migratory survivals through FCRPS facilities. PIT-tag based SAR estimates are a valuable information source to partition subbasin survival rates from survival rates through the Columbia mainstem migration corridor, during estuary and early ocean life, and for returning adults to Bonneville Dam and Sherars Falls.

No quantitative time series of smolts per adult or smolt-to-adult survival rates have been developed to represent wild Deschutes River populations across multiple generations. This type of information is important to monitor the productivity. This metric would help greatly to better understand the comparative productivity of Westside and Eastside populations. This is a high priority objective.

Type of monitoring effort: Long-term status and trend monitoring.

Monitoring questions:

- What is the effect of Columbia River hydropower operation on steelhead smolt survival for the Deschutes River Eastside and Westside populations?
- What is the effect of Columbia River hydropower operation on returning adult steelhead originating from the Deschutes River Eastside and Westside populations?
- What are SAR rates for the Deschutes River Eastside and Westside populations?

Approach: PIT tags have been used successfully to measure the influence of hydropower operations on migrating salmonids (see Berggren et al. 2006; Schaller et al. 2007). ODFW has cooperated with the CSS study by PIT tagging steelhead smolts as they migrate out of the John Day River Basin. These PIT-tagged fish are subsequently monitored for detections at FCRPS facilities along the migration corridor at both juvenile and adult life stages using DART and PTAGIS databases. Detection probabilities of juvenile salmonids migrating downstream at FCRPS facilities are modeled using the SURPH analytical tool (Lady et al. 2003). Adult detection (purportedly 100%) is currently available at ladders on several dams including Bonneville and are expected in the near future at The Dalles dam.

Analysis: Juvenile survivals at each FCRPS facility can be estimated using the SURPH model. Adult survival between facilities will soon be possible by comparing detections at adult ladder facilities along the migration corridor. Rates can be expanded to population-

level impacts using the relative number of fish PIT tagged and abundance estimates generated from mark-recapture at RSTs.

Status: ODFW currently PIT tags emigrating smolts on Trout Creek. Presently, juvenile outmigrants are also trapped annually in the Warm Springs River by CTWSRO. Detections of these tagged fish at FCRPS facilities are automatically logged into the PTAGIS database. The number of smolts tagged will need to be increased.

Objective 8: Determine the effect of habitat degradation and habitat restoration activities on the abundance, productivity, and distribution of the Deschutes River populations.

This is a high priority objective.

Type of monitoring effort: Long term status and trend; long term implementation and compliance; long term effectiveness monitoring.

Monitoring questions:

- Status & Trend Monitoring—What is the current status and trend of steelhead habitat?
- Implementation and Compliance Monitoring—Has the management action been implemented in the prescribed manner and achieved its objectives?
- Effectiveness Monitoring—Have the management actions significantly influenced the viability of the Deschutes River steelhead populations?

Approach: Status and trend monitoring at the subbasin and population scale is best conducted by using a spatially explicit sampling approach such as the EMAP approach developed by the EPA. Measured habitat variables will be the same as previously described for the John Day populations. Remote sensing (TIR, LIDAR, and spatially referenced color imagery) is also appropriate and typically addresses spatial scales at watershed or larger landscapes.

Compliance monitoring of restoration projects incorporates record keeping and reporting of activities. Compliance monitoring will primarily conducted by the implementing entity and will include parameters identified in related work statements.

Effectiveness monitoring can be approached at the watershed or project spatial scales, and should preferably be directed at measures of abundance, survival, growth, etc. of steelhead or abiotic or biotic factors limiting their recovery. A modified BACI design (including spatial replication) is recommended for measuring the effectiveness of active restoration activities (Jones & Tonn 2004). For passive restoration activities, a BACI design that monitors trends through time may be appropriate. If comparisons are made to reference or control sites, they should be under similar environmental conditions experienced by the treatment site but outside the influence of treatment activities. Restoration implementing entities must coordinate with monitoring groups prior to action implementation—preferably several years in advance to allow measurement of pre-manipulation variables. Temporal scales must account for time lags related to life history and life cycle. Derived variables include

proportion of population-level parameter (e.g., abundance, production) influenced by restoration activity.

Analysis: If at the appropriate scale, direct comparisons of measured parameters with recovery criteria can be made. Otherwise, measures at smaller scales will need to be scaled up to determine if they would have desired responses at the population level.

Status: Implementation monitoring is ongoing for some programs, however, roll-up to the population level is not ongoing and some programs have limited monitoring.

Objective 9: Determine the effect of harvest on the abundance, productivity, and diversity of the Deschutes River populations.

Since 1979, recreational angling regulations have stipulated that all wild fish be released unharmed. Tribal harvest of wild steelhead since 1998 has also been restricted at Sherars Falls, where most tribal summer steelhead harvest occurs. From 1993 to 2003, the annual harvest of wild steelhead in this subsistence fishery averaged 34 fish, with a range from 0 to 135 per year (French and Pribyl 2004). Significant tribal harvest of steelhead continues to occur in the mainstem Columbia; however, the number of Deschutes origin fish harvested in this fishery is unknown.

During the past ten years (1993 to 2002) the average catch of wild steelhead in the recreational fishery from the mouth upstream to, but not including the Sherars Falls area, averaged 3,268 fish, with a range of 1,192 to 6,525 fish. Recreational angling regulations stipulated that all wild fish had to be released unharmed. During the same period the catch of hatchery origin steelhead for the same river reach averaged 2,665 fish, with a range from 779 to 5,120 fish. Most tribal summer steelhead harvest occurs in the dipnet/set net subsistence fishery concentrated at Sherars Falls. During the 10-year period from 1993 to 2003, tribal fishers at Sherars Falls had tribal regulations restricting the harvest of wild steelhead. The annual harvest of wild steelhead in this subsistence fishery averaged 31 fish, with a range from 0 to 135 per year (French and Pribyl 2004). Some limited hook and line harvest of wild summer steelhead by Tribal members does occur in areas upstream of Sherars Falls, primarily during the winter months. The number of wild summer steelhead harvested by tribal fishers in this fishery is not known. This is a high level priority.

Type of monitoring effort: Long term status and trends.

Monitoring questions:

- What is the annual fishing mortality rate that occurs outside of the Deschutes River subbasin?
- What is the annual fishing mortality rate that occurs within the Deschutes River subbasin?

Approach: Reinstating an expanded creel survey of the recreational fishery within the Deschutes River subbasin would enable an estimate of the effects of the fishery on the wild populations. Examine all fish for fin clips and external tags. Origin of out-of-basin hatchery

strays will be determined by collecting and identifying any coded-wire tags from fin-clipped fish. Fish will be scanned for coded-wire and PIT tags using portable detectors. If tags are detected, snouts from fish with coded-wire tags and those that are ventral-clipped should be removed for tag identification.

Analysis: The number of fin-clipped and natural-origin fish caught by interviewed anglers will be totaled and be used for an expanded estimate of the number of fin-clipped and natural-origin fish caught throughout season. Estimate of the incidental and/or directed fishing mortality on natural-origin steelhead will be calculated using published literature values. Proportion of total mortality imposed by fishing mortality will be estimated when combined with additional mortality information.

Status: Voluntary returns of tags from cooperating anglers have occurred sporadically over the past several years. ODFW should provide lead with aid of tribal agencies where jurisdiction overlaps.

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Oregon Middle Columbia River Steelhead Recovery Plan Appendices A through J

APPENDIX A: Participants—Conservation and Recovery Plan for Oregon Steelhead Populations Middle Columbia River Steelhead Distinct Population Segment

APPENDIX B: Oregon Mid-Columbia Steelhead Viability Assessments

APPENDIX C: Summary of Habitat Projects Completed within Oregon's Mid-Columbia River Steelhead Populations on Private and Public Lands from 1995-2005 (Data provided by OWEB, USFS, BLM and Watershed Councils)

APPENDIX D: Hydropower Configuration and Operational Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations, and Estuary Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations

APPENDIX E: Forest Service and Bureau of Land Management Programs in Support of Mid-Columbia Steelhead Recovery Sufficiency Assessment

APPENDIX F: Habitat Programs Implemented by Oregon State Agencies to Address Limiting Factors and Threats to the Recovery of Listed Anadromous Salmon and Steelhead

APPENDIX G: Culverts which need to be improved or replaced

APPENDIX H: Management Actions Effectiveness Model Data and Assumptions

APPENDIX I: Cost Estimates for Recovery Actions

APPENDIX J: Fuels Treatment as an Action Contributing to Recovery of ESA-listed Anadromous Salmonids

APPENDIX A

Participants
Conservation and Recovery Plan for Oregon Steelhead Populations
Middle Columbia River Steelhead Distinct Population Segment

Sounding Board
Planning Team
Limiting Factors and Threats Expert Panel
Deschutes/Fifteenmile Management Action Team
John Day Basin Management Action Team
Umatilla/Walla Walla Management Action Team

Participants--Oregon Mid-Columbia Steelhead Recovery Plan

Sounding Board

Bruce Alyward	Deschutes River Conservancy
Ken Bailey	Irrigation (Board of Agriculture—The Dalles)
Brett Brownscombe	Oregon Trout
Paula Burgess	NOAA (Coordinator)
Chuck Burley	State Representative (forestry, AFRC)
Jody Calica	CTWSRO
Rich Carmichael	ODFW (State of Oregon Recovery Plan Coordinator)
Rick Craiger	OWEB
Al Doelker	BLM
Charlie Erickson	Sportsman
Rosemary Furfey	NOAA (Coordinator)
Patricia Gainsforth	SWCD--Deschutes, Tumalo Irrigation District
Ron Graves	SWCD--Wasco
Sue Greer	SWCD--Wheeler
Carlisle Harrison	Umatilla Basin Watershed Council
Lisa Hatley	Watershed Council--John Day
Brad Houslet	CTWSRO
Gary James	CTUIR
Suzanne Knapp	Governor's Natural Resources Office
Scot Lawrence	PGE
Lonny Macy	CTWSRO
Kevin Martin	USFS--Umatilla NF
Joe Moreau	BLM
Jo Morgan	ODF
Dave Payne	WEID
Don Ratliff	PGE
Marc Thalacker	TSID
Gary Thompson	Sherman County judge
Joe Whitworth	Oregon Trout
Brian Wolcott	Watershed Council--Walla Walla

Planning Team

Bob Bailey	DLCD
Tim Bailey	ODFW
Paula Burgess	NOAA
Rich Carmichael	ODFW (Chair and Plan Coordinator)
Rick Craiger	OWEB
Jackie Dougan	BLM
Rod French	ODFW
Mike Gauvin	CTWSRO/ODFW

Jerry Grant	ODFW
Rosemary Furfey	NOAA
Ellen Hammond	ODA
Scott Hoefer	NOAA
Elizabeth Klicker	OWRD
Bonnie Lamb	DEQ
Travis Medema	ODF
Eric Murray	NOAA
Nicole Navas	DSL
Kathy Ramsey	USFS
Jeff Rodgers	ODFW
Jesse Schwartz	CTUIR
Tom Straughn	ODA
Barbara Taylor	Consultant
Randy Tweten	NOAA
Eric Tinus	ODFW
Tim Unterwegner	ODFW
Gary Wade	NOAA
Jeff Weber	DLCD
Bob Young	ODF

Limiting Factors and Threats Expert Panel

Tim Bailey	ODFW
Ray Beamesderfer	Consultant
Mark Chilcote	ODFW
Rod French	ODFW
Chris Jordan	ODFW
Mike Gauvin	CTWSRO/ODFW
Chris Jordan	NOAA
Sue Knapp	ODFW
Hiram Li	OSU
Michelle McClure	NOAA
Dale McCullough	CRITFC
Jay Nicholas	ODFW (facilitator)
Jeff Rodgers	ODFW (facilitator)
Jim Ruzycki	ODFW
Tim Unterwegner	ODFW

Deschutes/Fifteenmile Management Action Team

Gary Asbridge	USFS (Hood River)
Bob Bailey	DLCD
Rick Craiger	OWEB
Jen Clark	SWCD (Wasco)
Jim Eisner	BLM
Rod French	ODFW
Mike Gauvin	CTWSRO/ODFW
Ron Graves	SWCD (Wasco)
Ellen Hammond	ODA
Scott Hoefer	NOAA
Brad Houslet	CTWSRO
Bonnie Lamb	DEQ
Steve Marx	ODFW
Travis Medema	ODF
Tom Rien	ODFW
Dan Rife	USFS (Deschutes and Ochoco)
Jeff Rodgers	ODFW
Chris Rossel	USFS (Barlow)
Dan Shively	USFS (Mt. Hood)
Barbara Taylor	Consultant
Eric Tinus	ODFW
Bob Young	ODF

John Day Basin Management Action Team

Bob Bailey	DLCD
Linda Brown	CTWSRO
Rick Craiger	OWEB
Jason Faucera	SWCD (Sherman)
Sue Greer	SWCD (Wheeler)
Lisa Hatley	NF JD Watershed Council
Brad Houslet	CTWSRO
Gary James	CTUIR
Bonnie Lamb	DEQ
Travis Medema	ODF
John Morris	BLM
Kathy Ramsey	USFS
Dan Rife	USFS
Jim Ruzycki	ODFW
Tom Straughn	ODA
Barbara Taylor	Consultant
Rich Turner	NOAA
Tim Unterwegner	ODFW
Gary Wade	NOAA
Bob Young	ODF

Umatilla/Walla Walla Management Action Team

Bob Bailey	DLCD
Tim Bailey	ODFW
Rick Craiger	OWEB
Jackie Dougan	BLM
Jerry Grant	ODFW
Scott Hoefer	NOAA
Bonnie Lamb	DEQ
Eric Murray	NOAA
Kathy Ramsey	USFS
Jesse Schwartz	CTUIR
Tom Straughn	ODA
Bob Young	ODFW

Appendix B

Oregon Mid-Columbia Steelhead Viability Assessments

Viability assessments following the format provided by the ICTRT for the following populations:

Fifteenmile Creek Winter Steelhead
Deschutes River Eastside Summer Steelhead
Deschutes River Westside Summer Steelhead
Crooked River Summer Steelhead
Lower Mainstem John Day River Summer Steelhead
North Fork John Day River Summer Steelhead
Middle Fork John Day River Summer Steelhead
South Fork John Day River Summer Steelhead
Upper Mainstem John Day River Summer Steelhead
Umatilla River Summer Steelhead
Walla Walla River Summer Steelhead

Fifteenmile Creek Winter Steelhead Population

The Fifteenmile Creek winter steelhead population (Figure 1) is one of five extant populations in the Cascades Eastern Slope Tributaries MPG within the Mid-Columbia steelhead DPS. The Fifteenmile Creek population is the only population in the DPS that is classified as an entirely winter life history type.

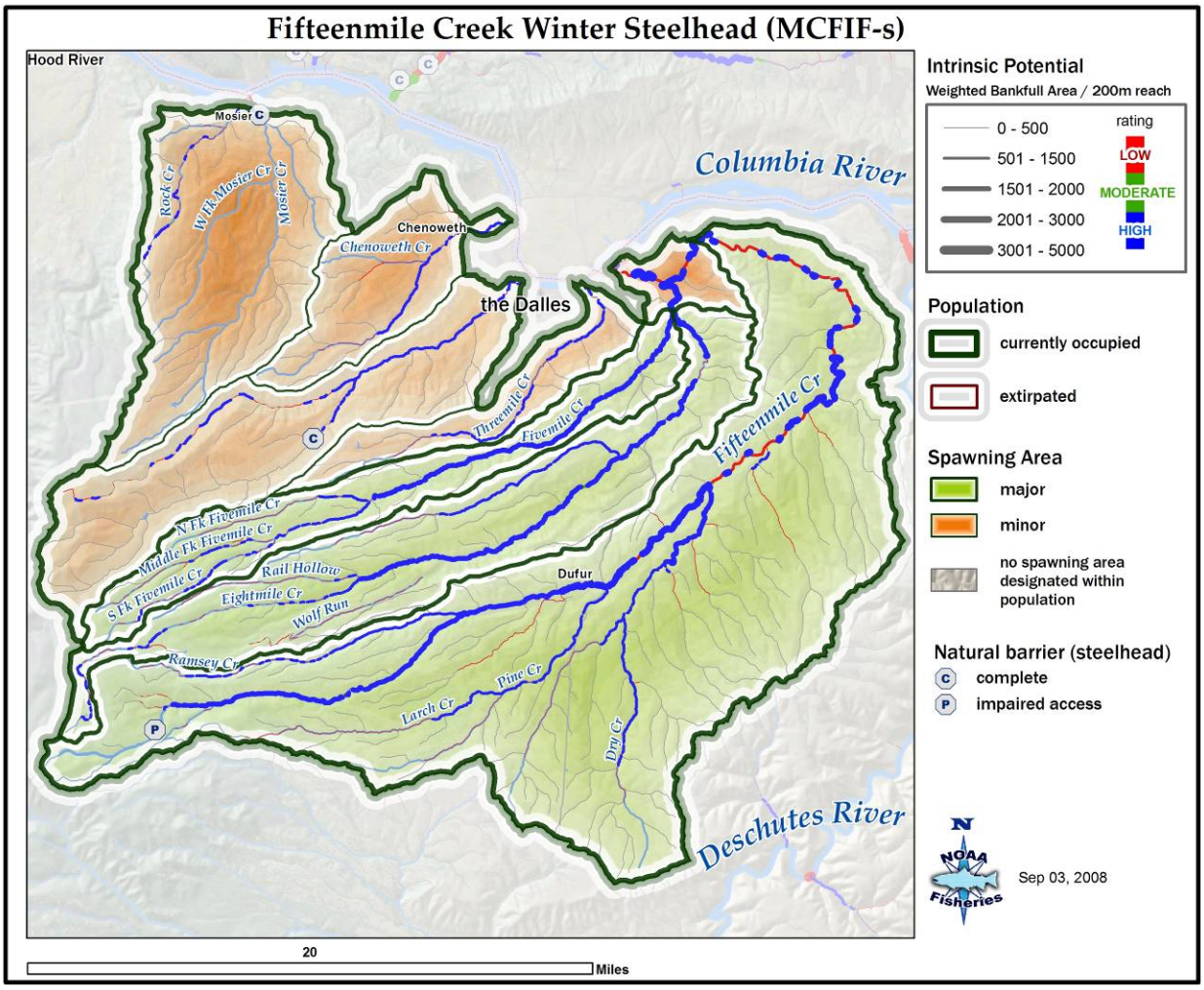


Figure 1. Fifteenmile Creek winter steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Fifteenmile Creek population as "basic" in size and complexity (Table 1). A steelhead population classified as basic has a mean minimum abundance threshold of 500 natural-origin spawners with sufficient intrinsic productivity (≥ 1.56 recruits per spawner at the abundance threshold level) to achieve a 5% or less risk of extinction over a 100-year timeframe. In order for the Fifteenmile Creek population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 2.00 recruits per spawner at the minimum abundance threshold.

Table 1. Fifteenmile Creek winter steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	1,420
Stream lengths km (total) [a]	638
Stream lengths km (below natural barriers) [a]	495
Branched stream area weighted by intrinsic potential (km^2)	1.816
Branched stream area km^2 (weighted and temp. limited) [b]	1.384
Total stream area weighted by intrinsic potential (km^2)	2.006
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	1.423
Size / Complexity category	Basic / "C" (trellis pattern)
Number of major spawning areas (MaSAs)	3
Number of minor spawning areas (MiSAs)	5

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

Current (1985 to 2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 231 in 1998 to 1,922 in 2004 (Figure 2). Estimates of abundance of adult steelhead spawners in the Fifteenmile Creek subbasin are based on redds observed during single pass spawning ground surveys conducted annually by the Oregon Department of Fish and Wildlife (ODFW) and U.S. Forest Service (USFS) personnel in selected survey units in upper Fifteenmile, Ramsey, and Eightmile creeks from 1985 through 2002. Since 2003, spawning ground surveys have been conducted in three passes over the duration of annual spawning activity in one-mile survey sites selected randomly from five-mile survey units stratified across the currently known spawning habitat in Fifteenmile, Ramsey, Eightmile, and Fivemile creeks. For this analysis, observations of redds and the locations of surveys have been compiled from DePinto et al. (2003), Glenney et al. (2004) and unpublished data (R. French, ODFW, personal communication 2005). Prior to 2003, we used redd densities in surveyed reaches to estimate redd densities in unsurveyed reaches. The ICTRT intrinsic potential analyses (ICTRT 2007) were used to estimate redds per weighted m^2 in surveyed reaches. To estimate total redds in the population, we multiply the number of redds per weighted m^2 in surveyed reaches by the total weighted m^2 of currently used habitat in the drainages where reaches were surveyed (ICTRT 2007). Historical intrinsic potential is estimated using a simple GIS-based model that accounts for differences across stream reaches (in terms of stream width, gradient, and valley width) and is further weighted by habitat quality.

For the 2003 and later years, observations of redds were expanded by the sample rate, both temporally and spatially, to estimate each season's total redds (redds/total spawning area/year). For years when streams in the Fifteenmile Creek subbasin were not surveyed (most notably Fivemile Creek prior to 2003) assumptions were made that spawning activity in unsurveyed streams was generally evenly distributed and synchronous with the entire population. Average proportional relations relative to the Fifteenmile Creek mainstem were used to estimate spawning activity in unsurveyed streams (Fivemile Creek redds represent approximately 15% of the Fifteenmile Creek mainstem redds).

The 2003-2005 multiple pass surveys have shown that spawning times can vary across years. Because the spawning ground surveys prior to 2003 were conducted once per season, variability in the time of spawning may be masked. However, spot checks were conducted to monitor the

level of spawning activity to determine when to conduct the surveys and recent investigations have shown that redd life (the length of time new redds remain visible) is sufficiently long to ensure that the observations from the historic single-pass surveys represent total spawning activity for each season (R. French, personal communication). Conversion of an annual total redd count to the adult population from 1985 to present assumes there are 2.1 fish per redd. This estimate was developed based on data from Deer Creek, a tributary to the Wallowa River (R. Carmichael, ODFW, personal communication,).

To estimate the abundance of adult progeny on the spawning grounds each season, consideration of removals of natural-origin fish for hatchery broodstock and natural spawning hatchery-origin fish must be accounted for. However, no steelhead hatchery program exists in the Fifteenmile Creek subbasin and hatchery steelhead are not released in steelhead habitat (Anonymous 2004). Further, hatchery strays in the Fifteenmile Creek subbasin have rarely been observed and the proportion is near 0%. Consequently for this analysis, the fraction of hatchery fish in the spawning population was assumed to be very low and mathematically assigned a value of zero.

Virtually no spawning steelhead in the Fifteenmile Creek subbasin have been sampled for age-at-return and no population specific information exists to assign natural-origin spawning fish into cohorts to estimate abundance of progeny. Therefore, age-at-return information from the closest natural-origin steelhead population with similar winter run traits was used to apportion Fifteenmile Creek steelhead spawners into brood years. Year specific age-at-return data for Hood River natural-origin winter steelhead sampled at Powerdale Dam were used. For those years with inadequate sample sizes, an average age-at-return by spawning year was applied.

Recent year natural spawners include only natural-origin fish. Hatchery strays in the Fifteenmile Creek population have rarely been documented.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 703 (Table 2). During the period 1985-1999, recruits per spawner (R/S, in terms of spawner to spawner) in the Fifteenmile Creek population ranged from 0.37 in 1987 to 5.58 in 1998. The annual R/S estimates were adjusted to reflect average smolt-to-adult return rates (SAR). The 15-year (1985-1999) geometric mean productivity was 1.82 R/S, adjusted for SAR and delimited at 75% (375 spawners) of the abundance threshold.

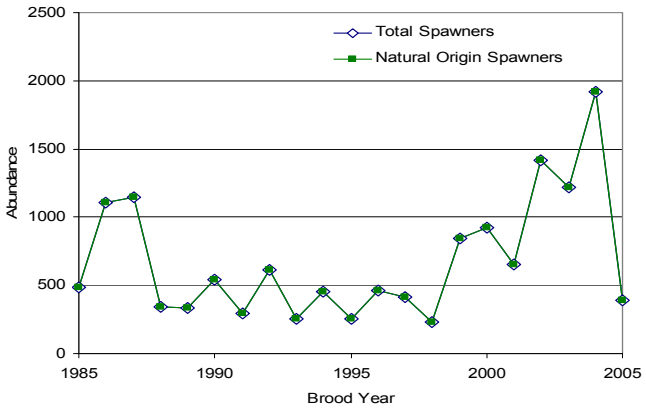


Figure 2. Fifteenmile Creek winter steelhead population spawner abundance estimates (1985-2005).

Table 2. Fifteenmile Creek winter steelhead population abundance and productivity estimates.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	703	(231-1,922)	
Proportion: natural-origin spawners (10-year geometric mean, range)	1.0	No obs. strays	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (15-year R/S, SAR adjusted and delimited) [a]	1.82	(1.23-2.68)	0.20
Productivity (15-year Beverton-Holt fit, SAR adjusted)	n/a		(n/a)
Trend Statistics (1985-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	1.03	(0.98-1.15)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	1.03	(0.83-1.28)	0.65
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.03	(0.83-1.28)	0.65

a. Delimited productivity excludes any recruit/spawner pair where the spawner number exceeds 75% of the abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Fifteenmile Creek winter steelhead population is at **Low Risk** based on current abundance and productivity. The point estimate for abundance and productivity resides above the 1% risk curve, but the population is not considered to be at very low risk since the 98% confidence interval (CI) extends below the 25% risk curve (Figure 3). However, since the 90% CI is above the 25% risk curve, the population is rated at low risk. Results should be viewed cautiously, as estimates are based on only 15 years of data.

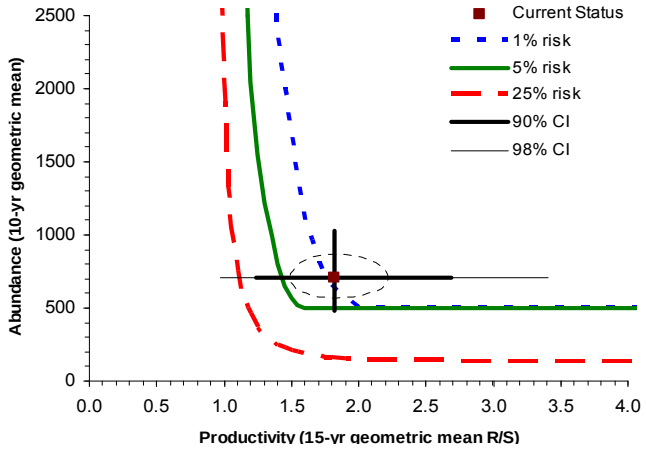


Figure 3. Fifteenmile Creek winter steelhead population current abundance/productivity (A/P) compared to DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A, 90% and 98% CIs for P (point estimate >1% risk curve; the uncertainty test is <1% probability the combined A/P is at high risk).

Both of the recent abundance trend metrics for this population indicate an average annual increase of approximately 3% per year over the period, driven largely by a relatively steady increase from 1999 through the 2004 return (Figure 2, Table 2). Abundance in 2005 decreased to similar levels observed from 1988 through 1998.

Spatial Structure and Diversity

The ICTRT has identified three major spawning areas (MaSAs) and five minor spawning areas (MiSAs) within the Fifteenmile Creek population boundaries. The population boundary extends outside the Fifteenmile Creek subbasin to encompass the Rock Creek, Mill Creek, and Threemile Creek drainages which directly enter the Columbia River downstream from Fifteenmile Creek (Figure 4). These drainages account for four of the five MiSAs. Current spawning distribution is similar to historic with major production areas in Fifteenmile, Ramsey, Eightmile and Fivemile creeks.

Spawners within the Fifteenmile Creek population include only natural-origin fish. Very few strays have been observed in the population and there is no hatchery program operated within the population. Additionally, there are few sources of winter steelhead strays in the interior Columbia River basin.

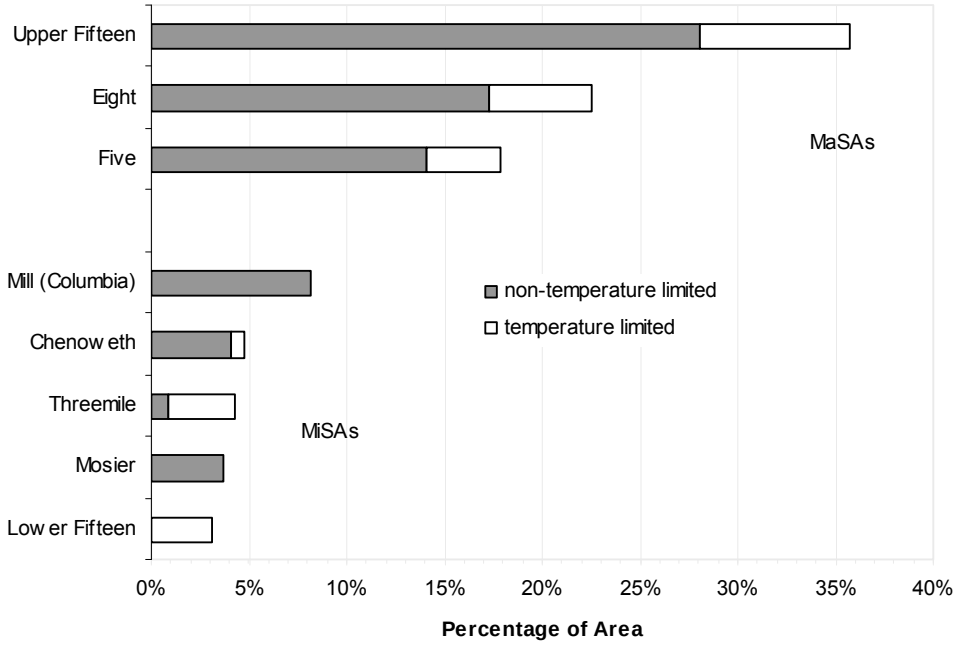


Figure 4. Fifteenmile Creek winter steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs). White bars represent current temperature limited areas that could potentially have had historical temperature limitations

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas

The Fifteenmile Creek population has three MaSAs and five MiSAs distributed in a trellis pattern. Historic major production areas included Fifteenmile, Ramsey, Eightmile and Fivemile creeks. Based on the ODFW current spawning distribution database, all three MaSAs and all five MiSAs are now occupied. Current distribution is similar to the historic intrinsic potential distribution, with reductions primarily in the southeast tributaries of the Fifteenmile MaSA. The Fifteenmile Creek population rates at **very low risk** because it has three occupied MaSAs and five MiSAs that equate to greater than 75% of one MaSA.

A.l.b. Spatial extent or range of population

The current spawner distribution mirrors the historic distribution with all MaSAs currently occupied (Figure 5). The rating for this metric is **very low risk** because the current spawning distribution mirrors the historic distribution. Spawning ground survey data are available for Fifteenmile, Ramsey, and Eightmile creeks for 1985-2005. We will conduct additional analyses at a later date to assess occupancy based on this recent survey data.

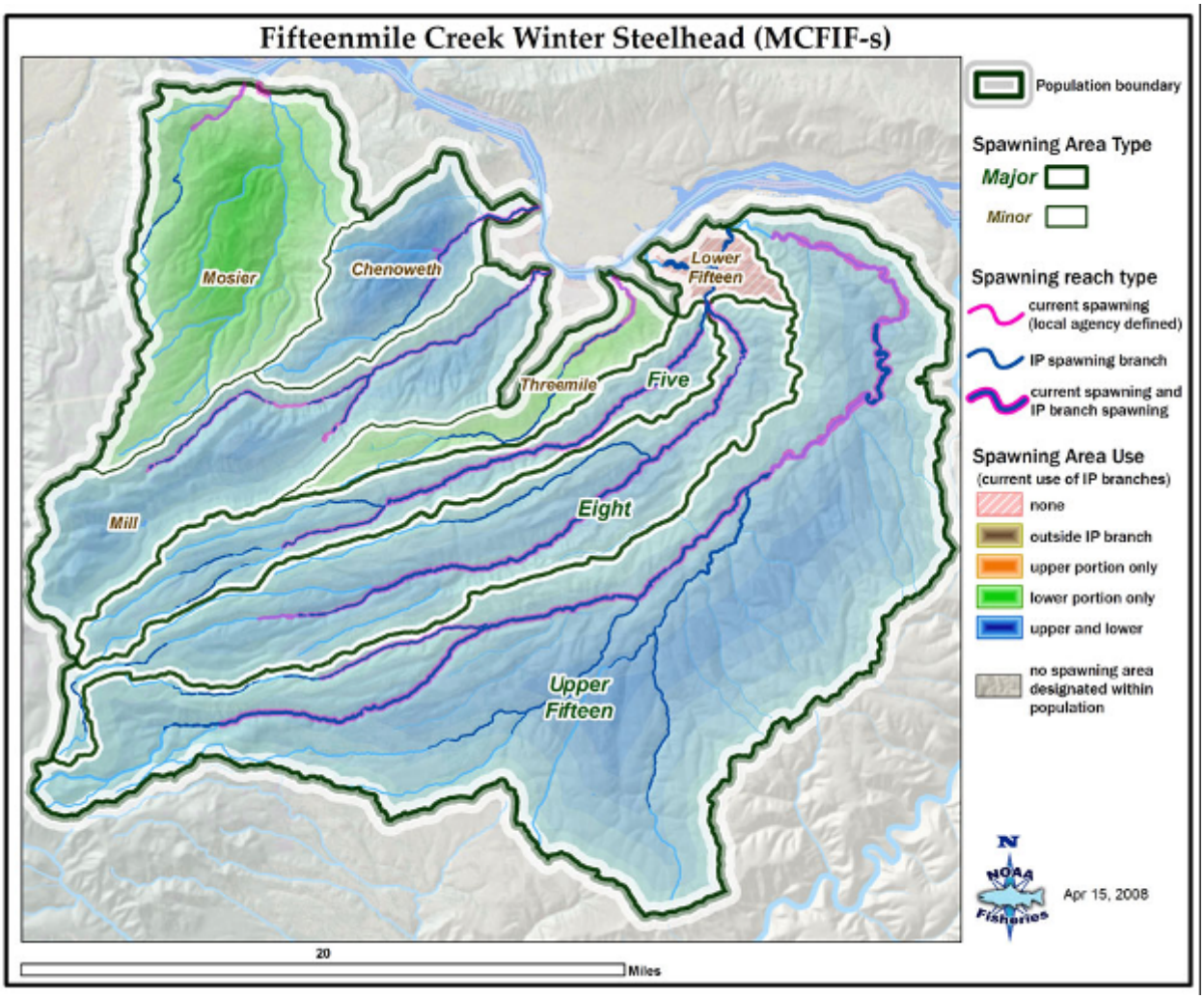


Figure 5. Fifteenmile Creek winter steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There has been little change in gaps between current and historical distribution. The population is rated at **very low risk** because all historical MaSAs are occupied, gap distance and continuity has changed little, and there has been no increase in distance between this population and other populations in the Mid-Columbia DPS.

B.1.a. Major life history strategies

There are limited data to allow any direct comparisons between historic life history strategies and current strategies. Flow and temperature changes have likely influenced movement pathways and continuity of habitat for juvenile steelhead. Some middle and lower mainstem reaches become uninhabitable during low flow summer periods. We infer that these habitat changes have truncated spawn timing and somewhat limited juvenile rearing diversity. Although these changes have had some influence on life history strategies, they have not likely influenced major strategies. The anadromous form of *O. mykiss* currently persists in the population and the winter

run characteristics have been maintained. We hypothesize that all historic major life history pathways are present, although the mean and variability may have shifted slightly. The rating is **low risk** for this metric.

B.1.b. Phenotypic variation

We have no direct evidence for loss or substantial change in phenotypic traits. However, changes in flow patterns and temperature profiles within Fifteenmile Creek subbasin have likely reduced variation in both juvenile migration timing and adult spawn timing. We hypothesize that low flows and elevated water temperatures result in a narrower window for successful smolt out-migration as well as truncation of adult spawn timing. However, the magnitude of the changes is likely small. Based on inference from habitat changes we have rated the Fifteenmile Creek population at **low risk**.

B.1.c. Genetic variation

Genetics data consist of samples from two locations within the Fifteenmile Creek population—Eightmile and Fifteenmile creeks. This genetics information indicates that the Fifteenmile Creek population is well differentiated from other populations in the Cascades Eastern Slope Tributaries MPG. Samples within the population from Eightmile Creek are also substantially differentiated from Fifteenmile Creek indicating within-population variation. We have rated this metric as **low risk**. Additional samples collected in 2005 from multiple locations within the population will provide a more robust dataset to assess this metric in the future.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners:* Out-of-DPS winter steelhead strays would originate from the Hood River hatchery program, from releases into the White Salmon River, and from other hatcheries downstream of Hood River. We have documented very few strays, thus the rating is **low risk**.

(2) *Out-of-MPG spawners from within the DPS:* There are no out-of-MPG within-DPS winter hatchery programs, thus the rating is **very low risk**.

(3) *Out-of-population spawners from within the MPG:* The only source of out-of-population within-MPG strays would be from the Klickitat River winter steelhead hatchery program. Since very few strays have been documented and their source is unknown, we have rated this metric as **low risk**.

(4) *Within-population hatchery spawners:* There is no within population hatchery program. This metric rated **very low risk**.

The overall spawner composition rating is **low risk**.

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution encompassed four ecoregions, of which three accounted for 10% or more of the distribution (Figure 6). Although there have been reductions in the proportional distribution of the Umatilla Plateau ecoregion, these reductions were not substantial. The population rates at **low risk**.

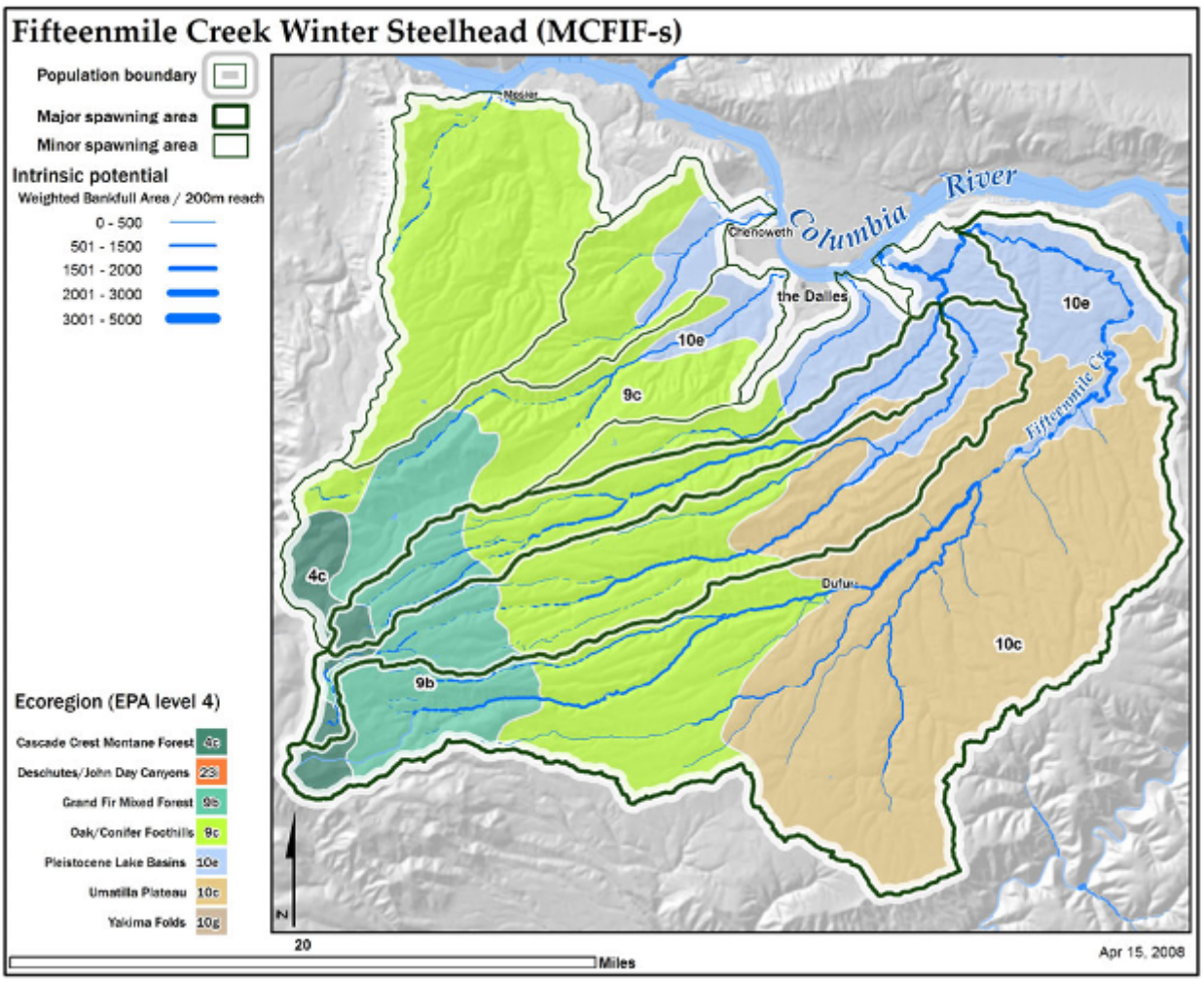


Figure 6. Fifteenmile Creek winter steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Fifteenmile Creek winter steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Grand Fir Mixed Forest	7.8	4.1
Oak/Conifer Foothills	36.4	41.2
Pleistocene Lake Basins	32.6	39.7
Umatilla Plateau	23.3	15.0

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes one dam in its seaward and spawning migrations, thus impacts on this population are relatively low. No traits are selectively affected by hydropower activity to the degree that they raise the risk level for this population. The rating is **low risk** for all traits.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be some very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery. While heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is no recreational fishery in the subbasin. No phenotypic traits appear to be at risk as a result of harvest activity and the rating is **low risk**.

Hatcheries: There are no steelhead hatchery programs operated within the population, therefore, there are no selective effects. The rating is **very low risk**.

Habitat: Altered flow profiles and increased temperatures in tributary spawning and rearing areas, which have been in place for many generations and are ongoing, likely impose some selection on juvenile and adult migration timing. However, the magnitude of the impact on any trait is negligible, thus the rating is **low risk** for all traits.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that is felt most strongly by the large steelhead smolts. The rate of predation is highest in May during nesting season. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selection is **low risk**.

No single trait has a moderate risk rating for any selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Low Risk** (Table 4) for the Fifteenmile Creek population. There has been little change in distribution relative to the historic distribution. The absence of major reductions in distribution resulted in a rating of very low risk for spatial structure metrics. We hypothesize that there have been minor reductions in life history diversity and phenotypic variation, but these changes are not severe enough to raise risk levels to moderate. There are few hatchery fish in the population resulting in low risk for spawner composition.

Table 4. Fifteenmile Creek winter steelhead population spatial structure and diversity risk rating.

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	VL (2)	VL (2)	Very Low Risk (Mean = 2)	Very Low Risk (Mean = 2)	**Low Risk**
A.1.b	VL (2)	VL (2)			
A.1.c	VL (2)	VL (2)			
B.1.a	L (1)	L (1)	Low Risk (1)	Low Risk (Mean = 1)	
B.1.b	L (1)	L (1)			
B.1.c	L (1)	L (1)			
B.2.a(1)	L (1)	Low Risk (1)	Low Risk (1)		
B.2.a(2)	VL (2)				
B.2.a(3)	L (1)				
B.2.a(4)	VL (2)				
B.3.a	L (1)	L (1)	L (1)		
B.4.a	L (1)	L (1)	L (1)		

Overall Viability Rating

The Fifteenmile Creek winter steelhead population currently meets ICTRT viability criteria and is rated as a **VIABLE** population (Figure 7). Overall abundance and productivity is rated at **Low Risk.** The 10-year geometric mean abundance of natural-origin spawners is 703, which exceeds the minimum abundance threshold of 500. The 15-year geometric mean productivity (1.82 R/S; Table 6) exceeds the 1.56 R/S required at the minimum abundance threshold. Overall spatial structure and diversity is also rated at **Low Risk.** A relatively small increase in productivity and a substantial reduction in the CI are required to move this population into "highly viable" status. Additional data will likely decrease the standard error and move the 98% CI out of the high risk region. These results should be viewed with caution, as abundance and productivity estimates for the Fifteenmile Creek population are based on only 15 years of R/S data. Monitoring should be continued to allow analysis of a longer time series.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V** **Fifteenmile Creek**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M**	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. Fifteenmile Creek winter steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Fifteenmile Creek Winter Steelhead Population

Data type: Expansions from multiple pass surveys in major tributary spawning reaches. Annual index area counts expanded to total population abundances using ratio of total to index area weighted intrinsic habitat (ICTRT 2007, Appendix C). Assumed 2.1 fish per redd.

SAR: Mid-Columbia steelhead composite series (see *Methods* section).

Table 5. Fifteenmile Creek winter steelhead population abundance and productivity data used for curve fits and R/S analysis. Bolded values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1985	484	1.0	484	383	0.79	0.46	176	0.36
1986	1109	1.0	1109	470	0.42	0.94	443	0.40
1987	1144	1.0	1144	424	0.37	2.18	922	0.81
1988	**340**	**1.0**	**340**	**529**	**1.56**	**0.99**	**524**	**1.54**
1989	**333**	**1.0**	**333**	**252**	**0.76**	**0.96**	**242**	**0.73**
1990	542	1.0	542	423	0.78	2.83	1196	2.21
1991	**291**	**1.0**	**291**	**265**	**0.91**	**2.33**	**618**	**2.12**
1992	611	1.0	611	446	0.73	1.88	838	1.37
1993	**257**	**1.0**	**257**	**443**	**1.72**	**1.18**	**524**	**2.04**
1994	456	1.0	456	344	0.75	1.07	369	0.81
1995	**257**	**1.0**	**257**	**569**	**2.21**	**1.23**	**697**	**2.71**
1996	465	1.0	465	1216	2.62	1.03	1255	2.70
1997	412	1.0	412	830	2.01	0.76	633	1.54
1998	**231**	**1.0**	**231**	**1292**	**5.58**	**0.49**	**633**	**2.74**
1999	844	1.0	844	1385	1.64	0.52	717	0.85
2000	925	1.0	925					
2001	655	1.0	655					
2002	1421	1.0	1421					
2003	1220	1.0	1220					
2004	1922	1.0	1922					
2005	388	1.0	388					

Table 6. Fifteenmile Creek winter steelhead population geometric mean abundance and productivity estimates (values used for current productivity area shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		
delimited	median	75% threshold	median	75% threshold	1988-1999	1985-1999	Nat. origin geomean
Point Est.	1.73	1.68	1.77	1.82	1.10	1.04	703
Std. Err.	0.25	0.29	0.17	0.20	0.06	0.11	0.21
count	7	6	7	6	12	15	10

Table 7. Fifteenmile Creek winter steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.17	0.21	n/a	n/a	0.40	0.44	37.1	1.27	0.21	n/a	n/a	0.38	0.33	34.8
Const. Rec	533	72	n/a	n/a	n/a	n/a	28.2	579	78	n/a	n/a	n/a	n/a	27.9
Bev-Holt	50.00	386.27	547	135	0.16	0.66	31.3	7.59	13.49	709	293	0.26	0.05	30.8
Hock-Stk	2.41	15.98	221	1465	0.16	0.65	31.3	2.56	29.41	226	2595	0.27	-0.04	31.1
Ricker	2.70	0.78	0.00161	0.00049	0.17	0.64	32.1	2.58	0.73	0.00137	0.00048	0.27	0.03	31.4

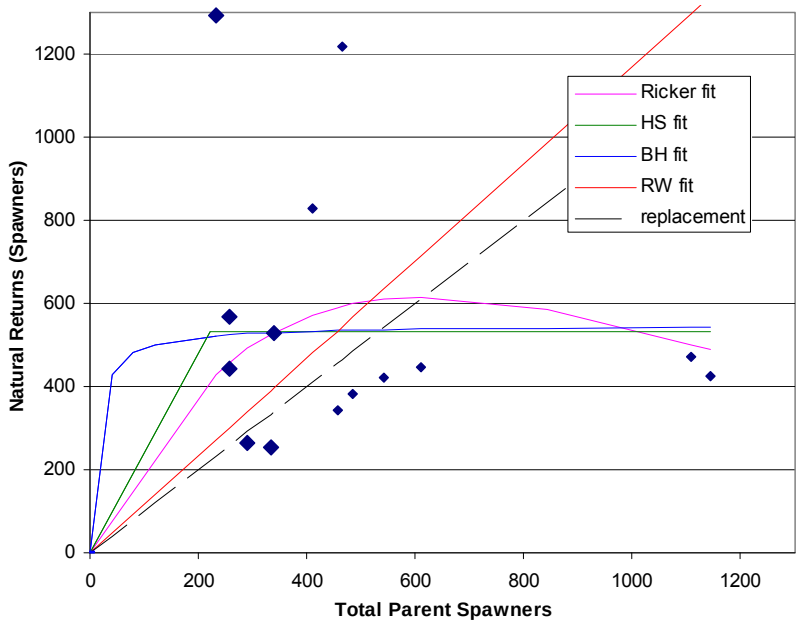


Figure 8. Fifteenmile Creek winter steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

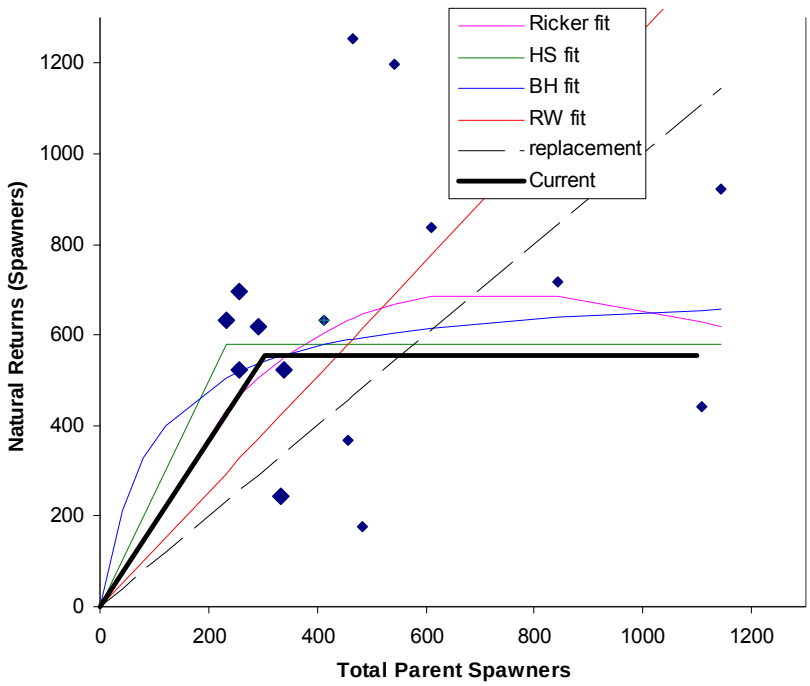


Figure 9. Fifteenmile Creek winter steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Deschutes River Eastside Summer Steelhead Population

The Deschutes River Eastside summer steelhead population (Figure 1) is one of five extant populations in the Cascades Eastern Slope Tributaries MPG within the Mid-Columbia steelhead DPS.

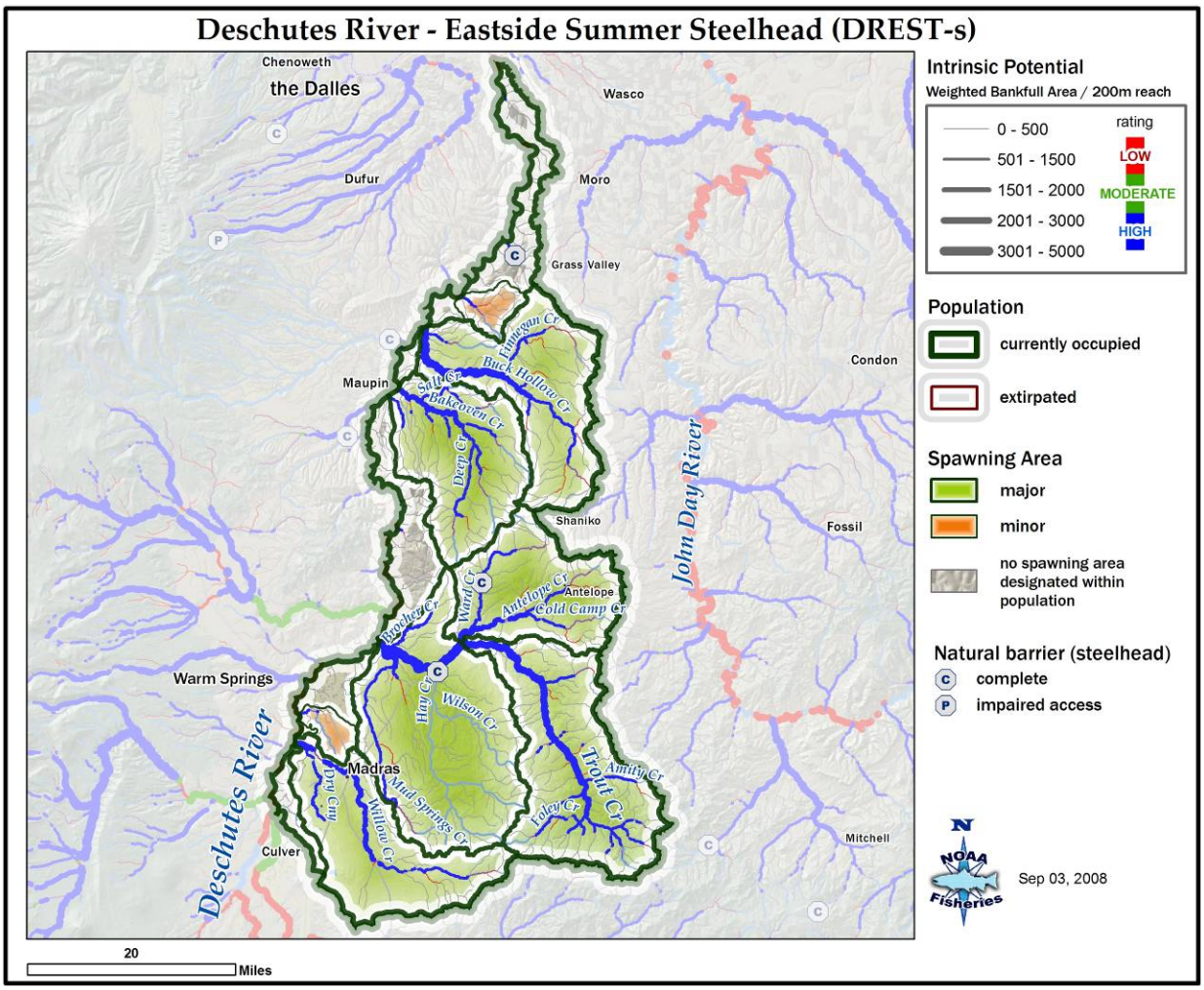


Figure 1. Deschutes River Eastside summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Deschutes River Eastside population as "intermediate" in size and complexity (Table 1). A steelhead population classified as intermediate has a mean minimum abundance threshold of 1,000 natural-origin spawners with a sufficient intrinsic productivity (≥ 1.35 recruits per spawner at the abundance threshold level) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the Deschutes River Eastside population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.64 recruits per spawner at the minimum abundance threshold.

Table 1. Deschutes River Eastside summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	3,889
Stream lengths km (total) [a]	974
Stream lengths km (below natural barriers) [a]	884
Branched stream area weighted by intrinsic potential (km^2)	2.780
Branched stream area km^2 (weighted and temp. limited) [b]	1.772
Total stream area weighted by intrinsic potential (km^2)	4.082
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	2.253
Size / Complexity category	Intermediate / "B" (dendritic structure)
Number of major spawning areas (MaSAs)	6
Number of minor spawning areas (MiSAs)	2

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

Current (1990 to 2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 583 in 1993 to 9,801 in 2001 (Figure 2). Current abundance of natural-origin adult spawners ranged from 299 in 1993 to 8,274 in 2001 (Figure 2). We examined two approaches for estimating the abundance of natural-origin and hatchery-origin steelhead in the Deschutes River Eastside population and selected one for this viability assessment. The first approach is similar to that used by Chilcote (2001) who conducted stock recruitment analyses for the combined Deschutes River Eastside and Westside populations. This method used the following information: estimated number of steelhead that pass above Sherars Falls (from mark-recapture estimates); the number of fish recovered in fisheries and traps above Sherars Falls; and estimated fall back rate for hatchery fish. We conducted similar analyses for the Deschutes River Eastside population with the additional step of subtracting out the Westside population abundance estimates. We found that this approach yielded, what appeared to be, extremely high abundance estimates of both natural-origin and hatchery-origin spawners for the Deschutes River Eastside population. Using this method resulted in a high number of spawners in the mainstem Deschutes River that was not consistent with the two years of redd observations data. We were unable to adequately quantify Sherars Falls fallback rates for natural-origin and hatchery-origin fish. The Sherars Falls mark-recapture subtraction approach is very sensitive to the fall back estimates, so in the absence of accurate estimates, we chose to use an alternative approach.

We chose to assess abundance and productivity based on estimates of spawners in the tributary production areas including Buck Hollow, Bakeoven, and Trout creeks. We acknowledge that this approach does not account for mainstem abundance and productivity. However, we believe this approach provides a better representation of the abundance and productivity for the Deschutes River Eastside population.

Estimates of the abundance of steelhead in the tributary production areas of the Eastside population are based on single pass index spawning ground surveys in the major spawning areas (MaSAs) of Trout, Bakeoven, and Buck Hollow creeks. Annual observations of redds begin with the 1990 spawning year in Bakeoven and Buck Hollow creeks, and 1993 in Trout Creek (excluding 1994). Spawning also occurs in the mainstem, but only two surveys have been conducted in the mainstem downstream of Trout Creek and this portion of the Eastside population is not included in this assessment.

To estimate spawning abundance, observed redd densities (redds/m^2) were extrapolated to unsurveyed areas of currently occupied spawning habitat. Variability in spawning habitat quality and capacity are incorporated in the abundance estimate by using the ICTRT's historical intrinsic potential (ICTRT 2007) to expand redd observations per unit survey area to unsurveyed areas. The number of redds per weighted m^2 of intrinsic habitat in the index survey areas are multiplied by the total m^2 of weighed intrinsic habitat within each tributary production area. Total redds are determined as the sum of redds in Bakeoven, Buck Hollow, and Trout creeks. In Trout Creek in 1990-1992 and 1994, when surveys were not conducted, the Trout Creek abundance was assumed to be 1.44 times the sum of the Buck Hollow and Bakeoven Creek abundance estimates, based on the proportion of spawning habitat in Trout Creek relative to all three tributaries. Redds are expanded to fish by multiplying total redds by 2.1 fish per redd (R. Carmichael, Oregon Department of Fish & Wildlife, personal communication). This estimate was derived for summer steelhead in Deer Creek, a tributary of the Wallowa River.

Abundance of progeny by spawning year was estimated by apportioning the total spawning abundance estimate into hatchery and natural-origin fish. For years when at least ten fish were examined for the presence of adipose fins in each stream, the marked fish proportion was used for the hatchery fraction. Field observers believe that these estimates may be biased low because of difficulties observing adipose fins on live fish at a distance (R. French, Oregon Department of Fish & Wildlife, personal communication). For years when fewer than ten fish were observed, the hatchery fraction was estimated based on the average ratio of the percentage of hatchery fish at Sherars Falls and the percentage of hatchery fish on the spawning grounds in Buckhollow and Bakeoven Creeks across all years. For Trout Creek we used the relationship of hatchery fraction between Trout Creek and Warm Springs National Fish Hatchery.

Virtually no spawning steelhead in the Deschutes River Eastside population have been sampled for age-at-return and no population specific information exists to assign natural-origin spawning fish into cohorts to estimate the abundance of progeny (Anonymous 2004). Age structure information used to estimate progeny by brood year was based on the average of a two-year sample of scales from natural-origin adult steelhead (N=100) collected in the lower Deschutes River (Olsen et al. 1991).

Recent year natural spawners include returns originating from naturally spawning parents, strays from the Deschutes Subbasin Round Butte Hatchery program, and a significant number of out-of-DPS hatchery strays from the Snake River basin. Origin of strays is based on recovery of coded-wire tagged fish in fisheries and at traps in the Deschutes River subbasin. Spawners originating from naturally spawning parents have comprised an average of 66% of naturally spawning fish since 1990. The percentage of natural-origin spawners has ranged from 21% to 88%.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 1,599. During the period 1990-1999, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Deschutes River Eastside population ranged from 0.24 in 1991 to 3.97 in 1996. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 10-year (1990-1999) geometric mean productivity was 1.89 R/S, adjusted for SAR and delimited at the median number of spawners (1,312; Table 2).

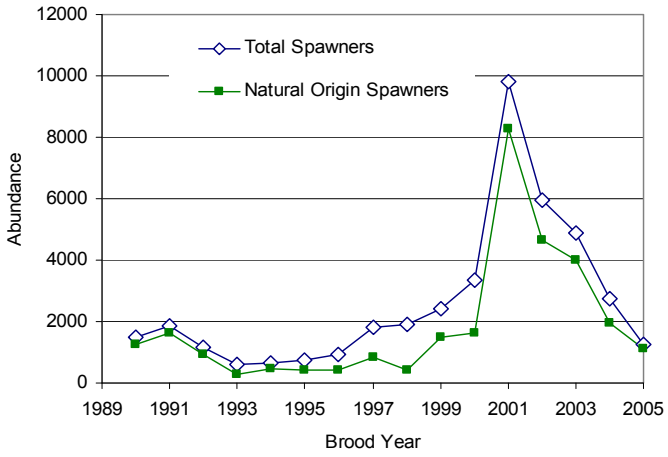


Figure 2. Deschutes River Eastside summer steelhead population spawner abundance estimates (1990-2005).

Table 2. Deschutes River Eastside summer steelhead population abundance and productivity estimates.

Abundance/Productivity Statistics	**Estimate**	**(Range)**	
Abundance: natural-origin spawners (10-year geometric mean, range)	1,599	(583-9,801)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.62	(0.21-0.88)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (10-year R/S, SAR adjusted & delimited) [a]	1.88	(1.10-3.26)	0.24
Productivity (15-year Beverton-Holt fit, SAR adjusted)	3.94		3.83
Trend Statistics (1990-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	1.11	(1.01-1.23)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	0.98	(0.53-1.79)	0.44
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.09	(0.55-2.15)	0.68

a. Delimited productivity excludes any recruit/spawner pair where the spawner number exceeds the median escapement. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Deschutes River Eastside population is at **Low Risk** based on current abundance and productivity. The point estimate for abundance and productivity resides above the 1% risk curve, but the population is not considered to be at very low risk since the lower end of the 98% confidence interval (CI) for productivity extends below the 25% risk curve. The 90% CI is above the 25% risk curve and the population is rated at low risk (Figure 3).

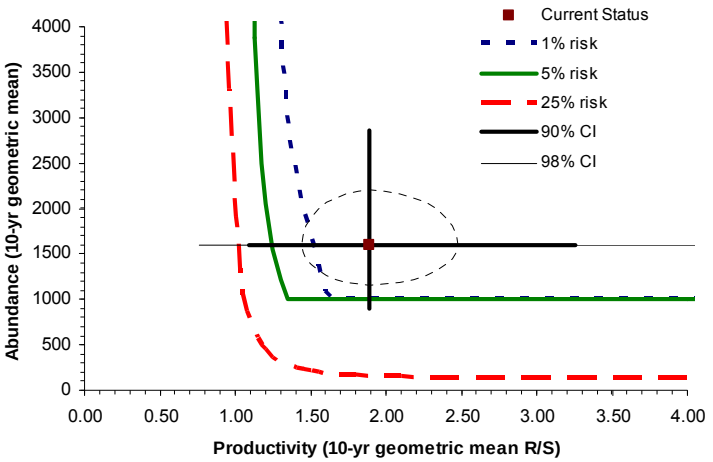


Figure 3. Deschutes River Eastside summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A, 90% and 98% CIs for P (point estimate >1% risk curve, therefore the uncertainty test results in <1% probability the combined A/P is at high risk).

On average, the trend in annual spawners (Table 2) has been positive since 1990, the first year data were available to generate estimates for this population. Both hatchery-origin and natural-origin returns showed similar patterns over the time period (Figure 2). Relatively high numbers of spawners in return years 2001-2003 contributed significantly to the average trend. In more recent years, annual spawning estimates have generally been at the levels observed in the initial years of the series. Under the assumption that hatchery and natural-origin parents were equally effective in contributing to natural production for this population (hatchery effectiveness = 1.0), the point estimate of population growth rate (λ) was below 1.0, with a 40% chance that the actual estimate exceeded 1.0. The relative effectiveness of hatchery-origin spawners in the Deschutes River Eastside population is not known. An estimate of the population growth rate was calculated assuming that hatchery returns did not effectively contribute to natural production (hatchery effectiveness = 0.0; Table 2). The estimated population growth rate assuming that hatchery spawners are not contributing to natural production was 1.09 (78% probability of exceeding 1.0).

Spatial Structure and Diversity

The ICTRT has identified six major spawning areas (MaSAs) and two minor spawning areas (MiSAs) within the Deschutes River Eastside steelhead population (Figure 4). The population boundaries extend above the Pelton Reregulation Dam, and therefore include areas that are currently inaccessible. One MaSA (Willow Creek) and one MiSA (Campbell) exist in the inaccessible area. The intrinsic potential analysis rated most of the Deschutes River mainstem spawning habitat as low potential because of the width and confinement, although steelhead spawning has been observed in the mainstem. Spawning is distributed broadly throughout the population boundaries. Steelhead production is concentrated in Buck Hollow, Bakeoven and Trout creeks, with some spawning in the mainstem from Trout Creek to Buck Hollow Creek. Spawners within the Deschutes River Eastside population include natural-origin returns, hatchery returns from Deschutes River origin fish produced from Round Butte Hatchery, and out-of-DPS hatchery strays primarily from the Snake River basin. Hatchery-origin fish comprise a significant proportion of the natural spawners.

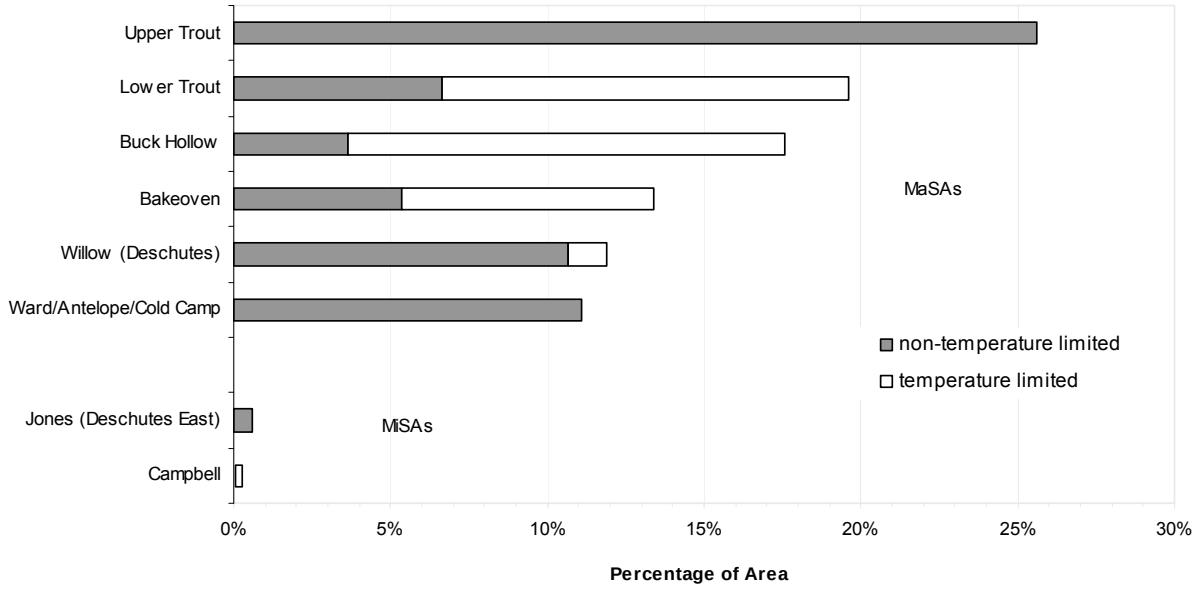


Figure 4. Deschutes River Eastside summer steelhead population distribution of intrinsic potential habitat across major and minor spawning areas. White bars represent current temperature limited areas that could potentially have had historical temperature limitations.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Deschutes River Eastside population has six MaSAs and two MiSAs distributed in a dendritic pattern (Figure 5). The primary production areas include Buck Hollow, Bakeoven, and Trout creeks. Historically, Willow Creek was also a significant production area. Based on the Oregon Department of Fish and Wildlife (ODFW) current spawner distribution database, five of the six MaSAs and neither of the two MiSAs are currently occupied. The MaSA that does not meet the occupancy criteria is Willow Creek. This MaSA is unoccupied because it is inaccessible. The Deschutes River Eastside population rates at **very low risk** for this metric because it has five MaSAs occupied in a non-linear configuration.

A.l.b. Spatial extent or range of population

The current spawner distribution is restricted somewhat from the historical distribution. The Willow Creek MaSA is unoccupied because it is inaccessible. There is also loss of spawning in the Jones and Campbell MiSAs (Figure 5). The population is rated at **low risk** for this metric because greater than 75% (but less than 90%) of the historic MaSAs are currently occupied.

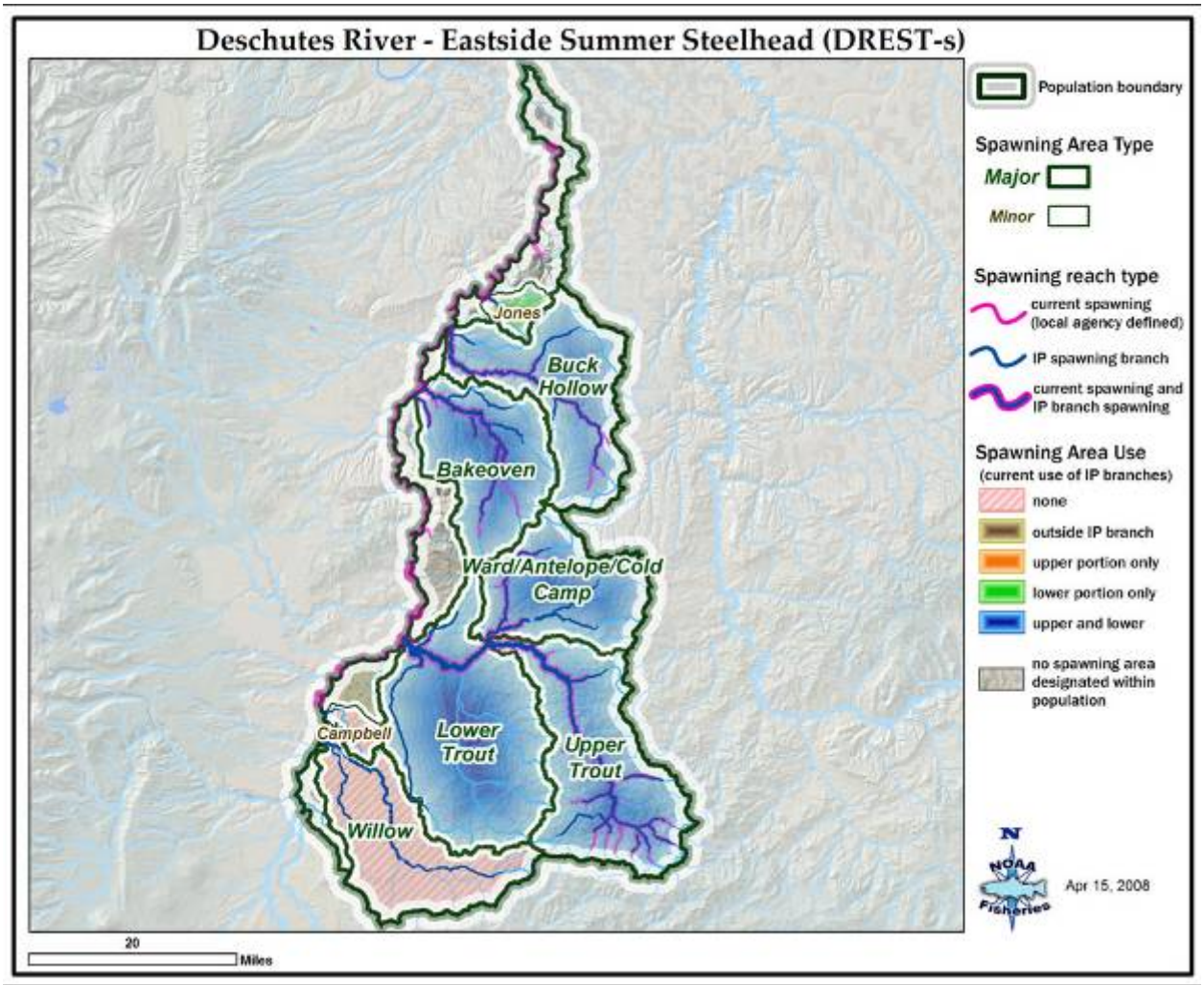


Figure 5. Deschutes River Eastside summer steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

The loss of spawning in the Willow Creek drainage has caused a significant increase in the gap distance between the uppermost spawning in the population and the middle production areas in Trout Creek. Currently, with the exception of the gap created by loss of spawning in Willow Creek, there is little difference in gaps and continuity between the historic and current distributions. We have rated the population at **low risk** for this metric.

B.1.a. Major life history strategies

There are no data to allow any direct comparison of historic and current major life history patterns, thus we must infer from habitat information. Flow and temperature changes within the major spawning tributaries have changed significantly relative to historic conditions with lower summer flows and higher temperatures. These changes have resulted in shifts in juvenile rearing patterns, with less summer rearing capacity in the tributaries and mandatory movement into either the mainstem or upper reaches for periods of summer rearing. Adult migration and spawn timing have likely been impacted by flow and temperature changes. Based on scale analyses of Deschutes River fish collected from the mainstem, the population demonstrates multiple ages at smolt migration and ocean residence time as well as repeat spawning. The habitat conditions, with mainstem rearing opportunities, do provide for opportunity for diverse life history strategies. We have rated the population at **low risk** for this metric.

B.1.b. Phenotypic variation

We have no direct observations to assess loss or substantial change in phenotypic traits, thus we must infer from habitat conditions and habitat changes through time. The flow and temperature changes in the tributaries have likely influenced both adult and juvenile migration timing and patterns. The loss of summer rearing opportunities forces juveniles to move downstream into the mainstem. Adult run-timing through the tributaries, as well as spawn timing, have likely been narrowed to some degree. We have rated this metric at **low risk** because two or more traits have likely changed and have reduced variability.

B.1.c. Genetic variation

There are limited genetics data for the Deschutes River Eastside population. The lower East Folley Creek samples were not significantly differentiated from other Eastside, Westside, or Round Butte Hatchery samples. However, the remaining samples from eastside tributaries show levels of differentiation between each other and between other populations that are consistent with a relatively unchanged structure. As a result of these data the population is rated at **low risk** for this metric. The ongoing genetics study that the U.S. Fish and Wildlife Service (USFWS) and co-managers are undertaking will yield additional and better information to assess this metric in the future.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners*: There are a significant number of out-of-DPS strays spawning naturally in the Deschutes River Eastside population. Estimates for stray hatchery proportions are derived from observations in Buck Hollow, Bakeoven, and Trout creeks. Since 1990, we estimated that hatchery strays have comprised from 12-90% of the spawners in this population, with a mean of 34.4% annually. We have no direct estimate of the proportion of out-of-DPS and Round Butte Hatchery strays for this population. Assuming the same proportion of out-of-DPS strays as we did for the Deschutes River Westside population (based on observations at Warm Springs National Fish Hatchery), we estimate that an average of 29% of the spawners in the Deschutes River Eastside population were out-of-DPS strays. Given this proportion and the duration of the influence we have rated the population at **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS*: There have been few out-of-MPG within-DPS strays recovered in the Deschutes River. The only source of this type of stray steelhead is from the Umatilla Hatchery program. We have rated this metric as **very low risk** due to the low proportion.

(3) *Out-of-population spawners from within the MPG*: Strays originating from the Round Butte Hatchery program are considered out-of-population within-MPG strays because their origin includes fish captured at the Pelton Reregulation Dam ladder and at Sherars Falls. The broodstock source likely includes both Westside and Eastside populations. Based on a total average hatchery proportion of 34.4% and the average proportion that Round Butte Hatchery strays make up of the total strays at Warm Springs National Fish Hatchery (15.5%), we estimated that Round Butte Hatchery strays comprise 5.4% of the naturally spawning fish annually. We have rated this metric as **moderate risk**.

(4) *Within-population hatchery spawners*: There are no within-population hatchery fish produced, thus we have rated this metric as **very low risk**.

The overall spawner composition rating is **high risk** due to the high proportion of out-of DPS strays that spawn naturally in this population.

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution encompassed five ecoregions of which three accounted for greater than 10% of the distribution. The current distribution is not significantly reduced from the historic distribution (Figure 6, Table 3). We have rated this metric at **low risk** because there were three historic ecoregions occupied and no substantial reductions.

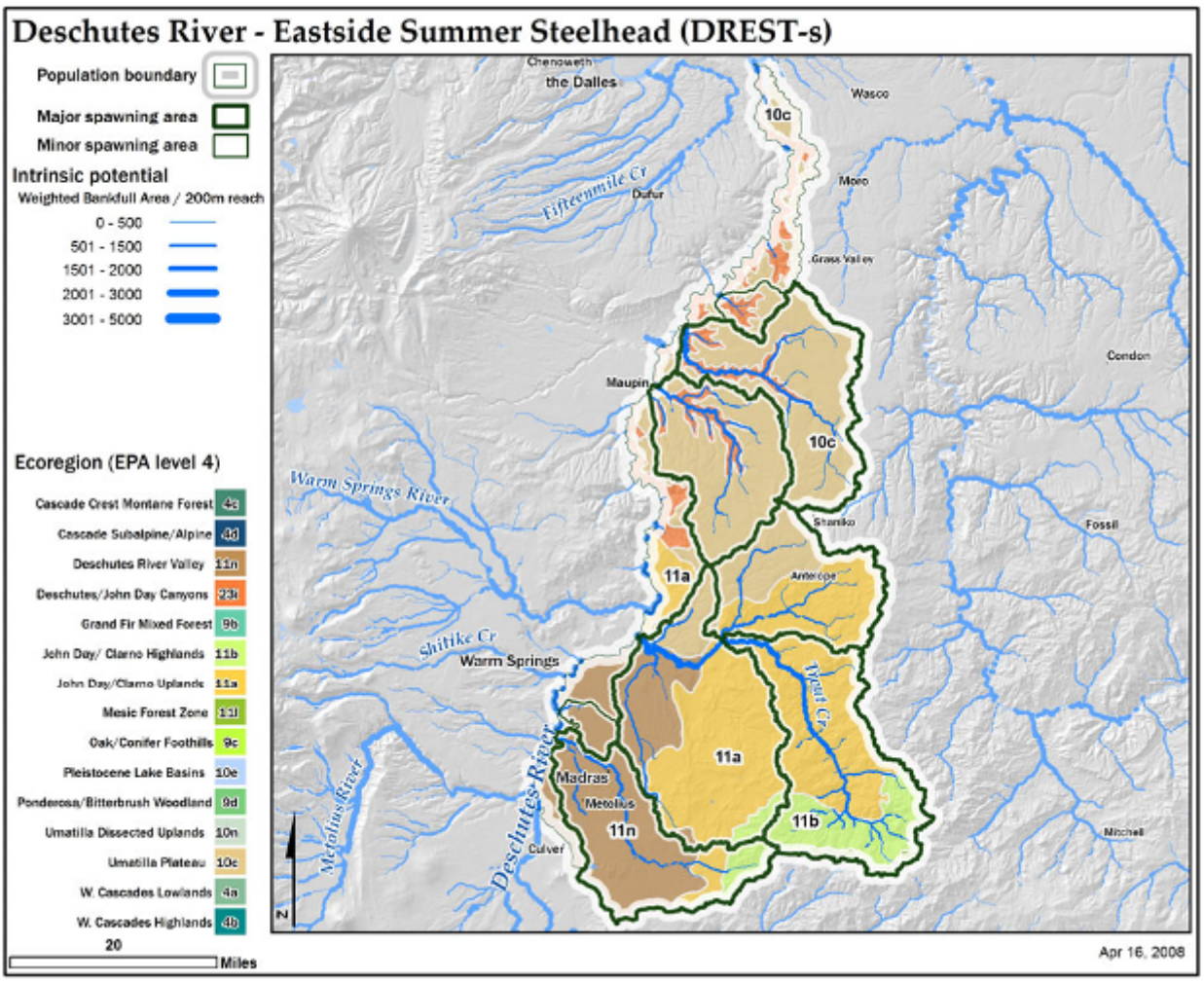


Figure 6. Deschutes River Eastside summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Deschutes River Eastside summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Deschutes River Valley	23.5	10.4
Deschutes / John Day Canyons	35.0	42.3
John Day Clarno Highlands	4.2	4.2
John Day Clarno Uplands	28.4	34.3
Umatilla Plateau	9.0	8.8

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes two dams in its seaward and spawning migrations, thus impacts on this population are relatively low. No traits are selectively affected by hydropower activity to the degree that they raise the risk level for this population. The hydropower rating is **low risk** for all traits.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is no selective impact of the recreational fishery. No phenotypic traits appear to be at risk as a result of harvest activity and the rating is **low risk** for all traits.

Hatcheries: There are no steelhead hatchery programs operated within the population; therefore, the hatchery rating is **very low risk**.

Habitat: Altered flow profiles and increased temperatures in tributary spawning and rearing areas, which have been in place for many generations and are ongoing, likely impose some selection on juvenile and adult migration timing, as well as spawn timing. However, the magnitude of selective mortality is likely negligible; therefore the habitat rating for all traits is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selection is **low risk**.

No single trait has a moderate risk rating for any selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** for the Deschutes River Eastside population (Table 4). The rating for Goal A (allowing natural rates and levels of spatially mediated processes) was **low risk**. Although the overall rating for this goal was low, spawning distribution is reduced significantly from the historic distribution with loss of spawning in the Willow Creek drainage being the primary factor. The population remains broadly distributed with little change in gaps and good continuity within the currently accessible habitat.

The rating for Goal B (maintaining natural levels of variation) was **moderate risk**. Habitat changes in key tributary production areas have likely resulted in limitations to life history diversity and reduction in phenotypic expression. In addition, a significant proportion of natural spawners are out-of-DPS strays which resulted in a high risk rating for the spawner composition metric. Additional genetics information is needed to assess differentiation within and between populations, as well as to improve our understanding of the degree of introgression of out-of-DPS strays. The ongoing genetics work of the USFWS and co-managers will provide the information needed to better assess the genetic health of this population.

Table 4. Deschutes River Eastside summer steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Low Risk
(Mean = 1.3)</td><td rowspan="3">Low Risk
(Mean = 1.3)</td><td rowspan="15">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>A.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Low Risk (1)</td><td rowspan="9">Moderate Risk
(Mean = 0.5)</td></tr>
<tr><td>B.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(3)</td><td>M (0)</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The overall rating for the Deschutes River Eastside summer steelhead population currently meets ICTRT viability criteria for **VIABLE** status (Figure 7). Overall abundance and productivity is rated at **Low Risk.** The 10-year geometric mean abundance of natural-origin spawners is 1,599, which is well above the minimum abundance threshold of 1,000. The 10-year geometric mean productivity (1.89 R/S; Table 6) exceeds the 1.35 R/S required at the minimum abundance threshold and puts the population into the very low risk region; however the 98% CI extends well below the 25% risk level. This wide standard error results in a low risk level for abundance/productivity. Overall spatial structure and diversity is rated at **Moderate Risk**. This is primarily a result of the influence of habitat changes on life history and phenotypic expression as well as the influence of out-of-DPS hatchery spawners.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V** **Deschutes River Eastside**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M**	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. Deschutes River Eastside summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M - Maintained; HR – High Risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Deschutes River Eastside Summer Steelhead Population

Data type: Expansions from single pass surveys in major tributary spawning reaches. Annual index area counts expanded to total population abundances using ratio of total to index area weighted intrinsic habitat (ICTRT 2007, Appendix C). Assumed 2.1 fish per redd.

SAR: Mid-Columbia steelhead composite series (see *Methods* section).

Table 5. Deschutes River Eastside summer steelhead population abundance and productivity data used for curve fits and R/S analysis. Bolded values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1990	1466	0.87	1270	432	0.29	2.83	1224	0.83
1991	1862	0.88	1640	447	0.24	2.33	1044	0.56
1992	**1158**	**0.82**	**948**	**549**	**0.47**	**1.88**	**1033**	**0.89**
1993	**583**	**0.51**	**299**	**718**	**1.23**	**1.18**	**848**	**1.46**
1994	**635**	**0.70**	**442**	**893**	**1.41**	**1.07**	**956**	**1.51**
1995	**740**	**0.59**	**436**	**1815**	**2.45**	**1.23**	**2224**	**3.01**
1996	**953**	**0.43**	**407**	**3786**	**3.97**	**1.03**	**3907**	**4.10**
1997	1829	0.46	841	6448	3.53	0.76	4922	2.69
1998	1921	0.21	401	4542	2.36	0.49	2227	1.16
1999	2397	0.61	1472	3236	1.35	0.52	1675	0.70
2000	3341	0.49	1627					
2001	9801	0.84	8274					
2002	5957	0.78	4665					
2003	4888	0.82	3984					
2004	2754	0.71	1945					
2005	1274	0.87	1114					

Table 6. Deschutes River Eastside summer steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted	SAR adjusted	
delimited	median	75% threshold	median	75% threshold	1990-1999	1980-1999	Nat. origin geomean
Point Est.	1.52	1.62	1.89	1.88	1.10	n/a	1599
Std. Err.	0.36	0.21	0.27	0.24	0.11	n/a	0.32
count	5	3	5	3	10	n/a	10

Table 7. Deschutes River Eastside summer steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.20	0.36	n/a	n/a	0.22	0.87	33.1	1.38	0.28	n/a	n/a	0.22	0.68	24.9
Const. Rec	1461	454	n/a	n/a	n/a	n/a	33.8	1672	307	n/a	n/a	n/a	n/a	23.2
Bev-Holt	1.92	2.00	4209	7419	0.16	0.91	37.1	3.94	3.83	2680	1554	0.15	0.72	26.4
Hock-Stk	1.20	0.21	19855	0	0.22	0.87	37.4	1.38	0.14	19729	0	0.22	0.68	29.2
Ricker	1.64	1.19	0.00023	0.00049	0.16	0.90	37.1	2.86	1.21	0.00054	0.00029	0.14	0.74	26.2

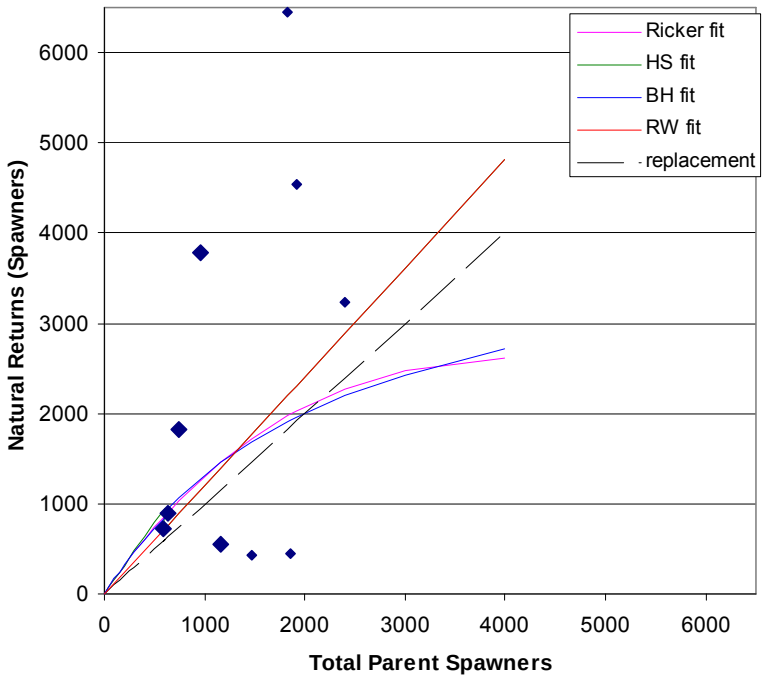


Figure 8. Deschutes River Eastside summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

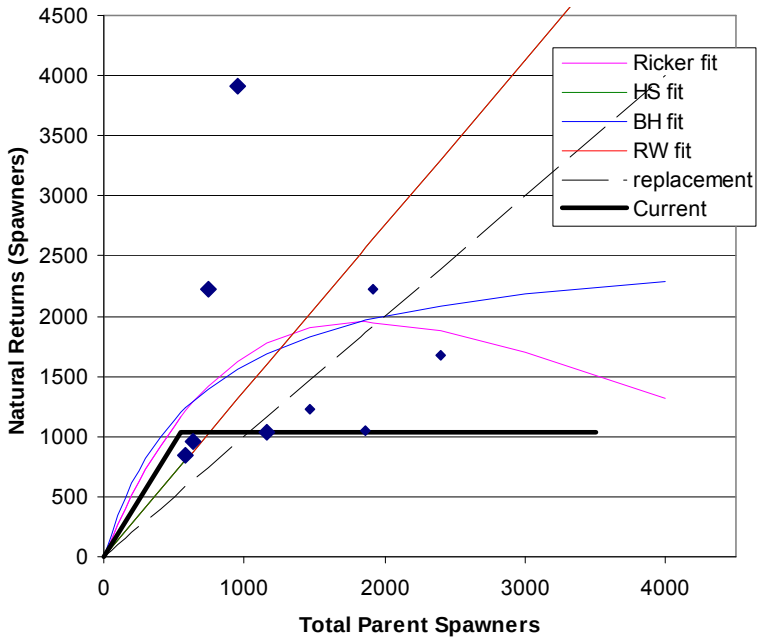


Figure 9. Deschutes River Eastside summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Deschutes River Westside Summer Steelhead Population

The Deschutes River Westside summer steelhead population (Figure 1, Figure 2) is one of five extant populations in the Cascades Eastern Slope Tributaries MPG within the Mid-Columbia steelhead DPS.

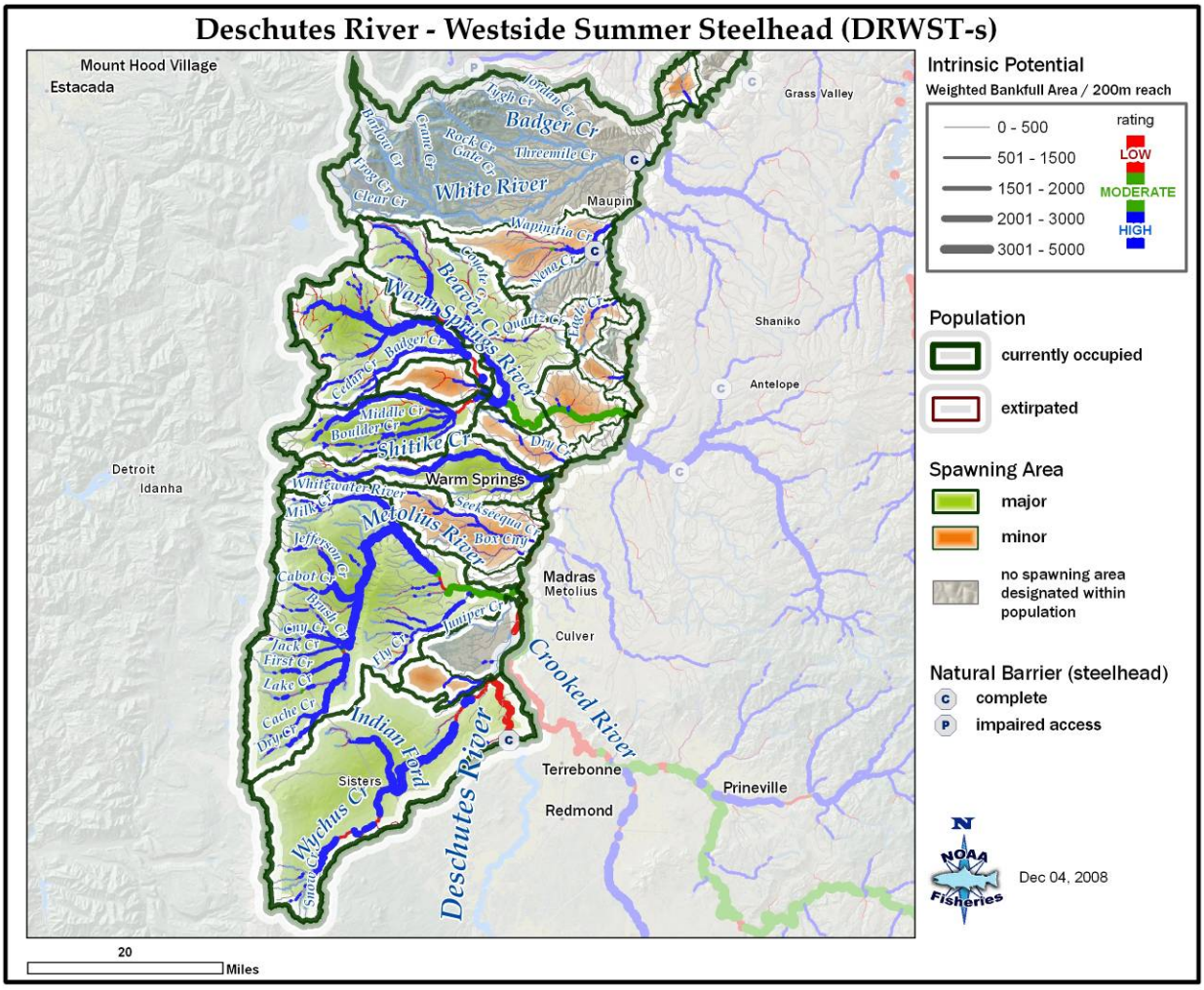


Figure 1. Deschutes River Westside summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas - currently accessible population areas.

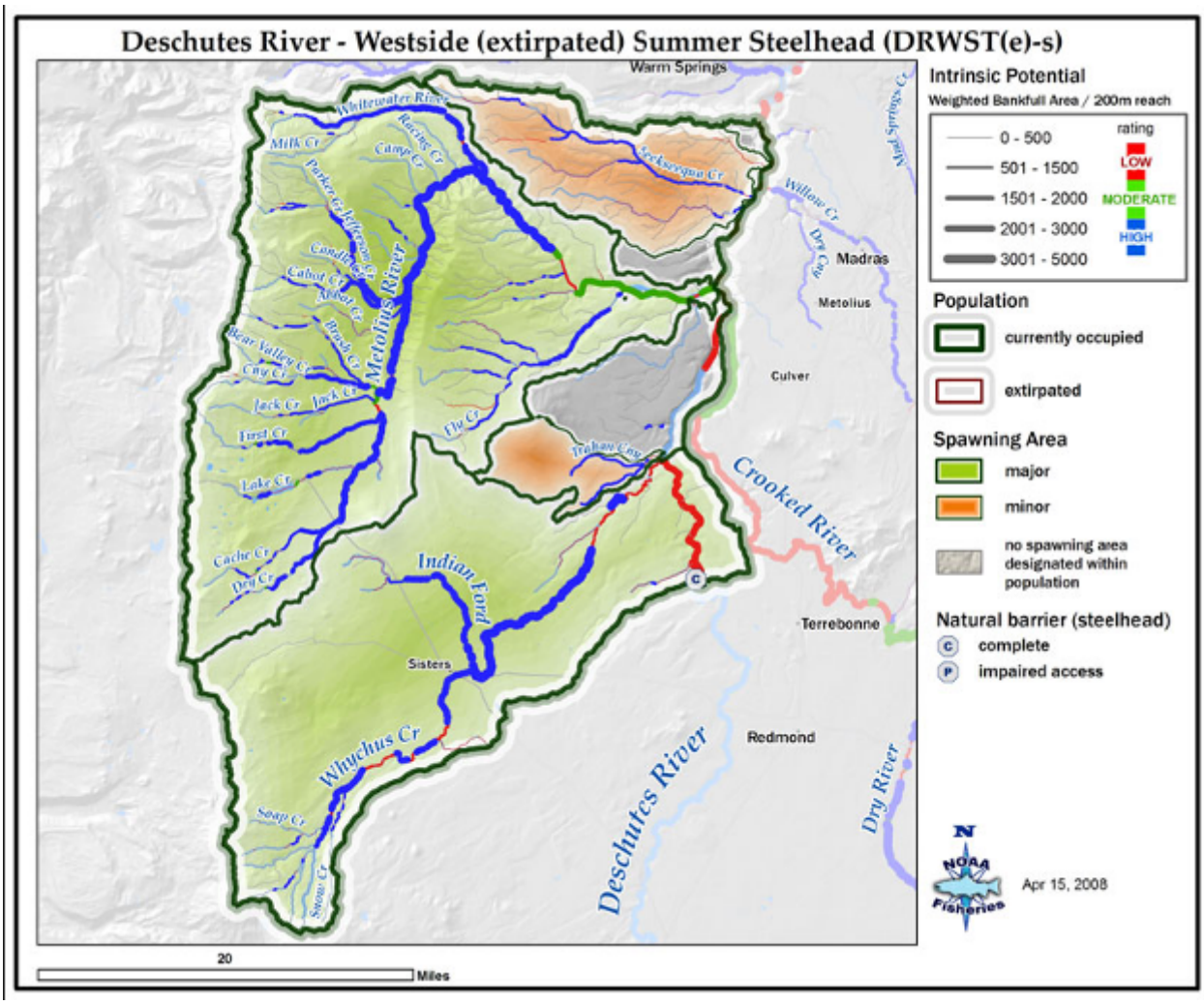


Figure 2. Deschutes River Westside summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas - historically accessible areas.

The Deschutes River Westside population can be classified as either "large" or "intermediate" in size and complexity depending on whether the classification is based on historically accessible habitat or currently accessible habitat. These size category options exist because access to a considerable amount of habitat is blocked by the Pelton-Round Butte dams within the population, with current spawning only below the barrier (Table 3.1.3-1). A steelhead population classified as large has a mean minimum abundance threshold of 1,500 natural-origin spawners with sufficient intrinsic productivity (≥ 1.26 recruits per spawner at the abundance threshold level) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. Alternatively, a steelhead population classified as intermediate has a mean minimum abundance threshold of 1,000 natural-origin spawners with sufficient intrinsic productivity (≥ 1.35 recruits per spawner at the abundance threshold) to achieve a 5% risk of extinction over 100 years. In this assessment we evaluate the population with the abundance/productivity (A/P) criteria for an intermediate sized population that assesses only the habitat below the Pelton Reregulation Dam. However, for the spatial structure/diversity (SS/D) assessment we evaluated the population based on the historic distribution and characteristics. Viable status for this population could not be

achieved using A/P criteria for a large population because current capacity is not adequate to meet abundance criteria.

Table 1. Deschutes River Westside summer steelhead population basin statistics and intrinsic potential analysis summary.

Metric	All areas	Currently Accessible areas
Drainage area (km^2)	6,060	3,619
Stream lengths km (total) [a]	2,230	1,511
Stream lengths km (below natural barriers) [a]	1,474	937
Branched stream area weighted by intrinsic potential (km^2)	5.51	2.65
Branched stream area km^2 (weighted and temp. limited) [b]	5.01	2.24
Total stream area weighted by intrinsic potential (km^2)	8.25	4.56
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	6.61	3.18
Size / Complexity category	Large / "B" (dendritic)	Intermediate / "B" (dendritic)
Number of major spawning areas (MaSAs)	6	4
Number of minor spawning areas (MiSAs)	9	7

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22°C.

Current Abundance and Productivity

Current (1978 to 2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 154 in 1996 to 1,548 in 2003 (Figure 3). Current abundance of natural-origin adult spawners ranged from 108 in 1996 to 1,283 in 2003 (Figure 3). Abundance estimates for the Deschutes River Westside population of adult spawning steelhead are the sum of abundance estimates for three components of the population:

- natural-origin fish upstream of the Warm Springs National Fish Hatchery (NFH) barrier dam at river kilometer (rkm) 16 in the Warm Springs River
- natural-origin and hatchery fish that ascend Shitike Creek
- natural-origin and hatchery-origin fish that remain in the mainstem Deschutes River and spawn from above the mouth of Trout Creek upstream to Pelton Reregulation Dam

The data series begins in the 1978 spawning year with census counts at Warm Springs NFH and in the 1982 spawning year with single pass spawning ground surveys in Shitike Creek index survey units in that cover 67% of the currently used spawning habitat. For the mainstem, single pass aerial surveys were conducted in 1995 and 2001 (Pribyl 1995 and 2001), and multiple pass surveys were conducted in 1996 and 1997 (Zimmerman and Reeves 2000).

To estimate spawning abundance in Shitike Creek, observed redd densities ($redds/m^2$) in surveyed reaches were used to estimate redd densities in unsurveyed areas. Variability in habitat quality and capacity throughout reaches in Shitike Creek is accounted for by using the ICTRT's historical intrinsic potential. The ICTRT intrinsic potential analyses were used to estimate redds per weighted m^2 of habitat in surveyed reaches. To estimate total redds in the population we multiplied the number of redds per weighted m^2 in surveyed reaches by the total weighted m^2 of currently occupied habitat in Shitike Creek (ICTRT 2007). Historical intrinsic potential is

estimated using a simple GIS-based model that accounts for differences across stream reaches in terms of stream width, gradient, and valley width that are further weighted by habitat quality. An expansion of 2.1 fish per redd was used to estimate annual spawner abundance (R. Carmichael, Oregon Department of Fish & Wildlife, personal communication). This estimate was derived for summer steelhead in Deer Creek, a tributary of the Wallowa River. For the 1978-1981 spawning years when spawning ground surveys were not conducted in Shitike Creek, the Shitike Creek abundance was assumed to represent 1.6% of the Sherars Falls escapement based on the average proportional relation between Shitike Creek and Sherars Falls escapement from 1982 to present.

Abundance estimates for the mainstem Deschutes River upstream of Trout Creek also assume 2.1 fish per redd. For years when spawning ground surveys were not conducted in the mainstem, an average relative proportion of observed spawning activity per number of fish escaping above Sherars Falls was applied to the Sherars Falls escapement (1.2%).

Abundance of progeny by spawning year is estimated by apportioning the total spawning abundance estimate into hatchery- and natural-origin fish. The proportion of hatchery fish entering Shitike Creek to spawn and hatchery fish remaining in the mainstem upstream of Trout Creek is assumed to be identical to the proportion of hatchery fish observed at the Warms Springs NFH barrier.

Virtually no spawning steelhead in the Deschutes River Westside population have been sampled for age-at-return, and no population specific information exists to assign natural-origin spawners into cohorts to estimate abundance of progeny (Anonymous 2004). Age structure information used to estimate progeny by brood year is based on the average of a two-year sample of scales from natural-origin adult steelhead (N=100) collected in the lower Deschutes River (Olsen, et al., 1991).

Recent year natural spawners include returns originating from naturally spawning parents, strays from the Deschutes Subbasin Round Butte Hatchery program, and a significant number of out-of-DPS hatchery strays from the Snake River. Natural-origin spawners have comprised an average of 82% of naturally spawning fish since 1978. The percentage of natural-origin spawners has ranged from 57% to 97%.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 456 (Table 2). During the period 1980-1999, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Deschutes River Westside population ranged from 0.24 in 1987 to 3.72 in 1996. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 20-year (1979-1998) geometric mean productivity was 1.05 R/S, adjusted for SAR and delimited at 75% (750 spawners) of the minimum abundance threshold (Table 2).

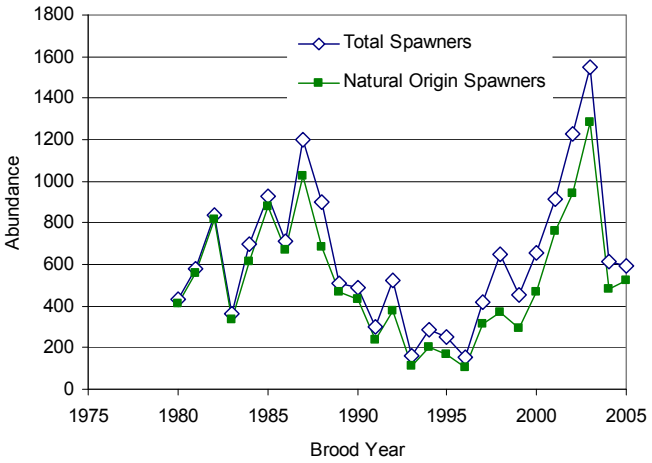


Figure 3. Deschutes River Westside summer steelhead population spawner abundance estimates (1978-2005).

Table 2. Deschutes River Westside summer steelhead population abundance and productivity estimates.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	456	(108-1283)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.75	(0.57-0.97)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (20-year R/S, SAR adjusted & delimited) [a]	1.05	(0.81-1.37)	0.15
Productivity (20-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	0.99	(0.96-1.17)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	0.97	(0.78-1.20)	0.35
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.02	(0.81-1.29)	0.58

a. Delimited productivity excludes any recruit/spawner pair where the spawner number > 75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Deschutes River Westside population is at **High Risk** based on current abundance and productivity. The point estimate for abundance and productivity resides below the 25% risk curve (Figure 4). The upper end of the 90% confidence interval (CI) for productivity extends slightly above the 25% risk curve but is not significant enough to lower the risk rating.

The average trend in abundance over the most recent 20 years has been just below 1.0 based on both the trend in ln(natural-origin spawner abundance) and the population growth

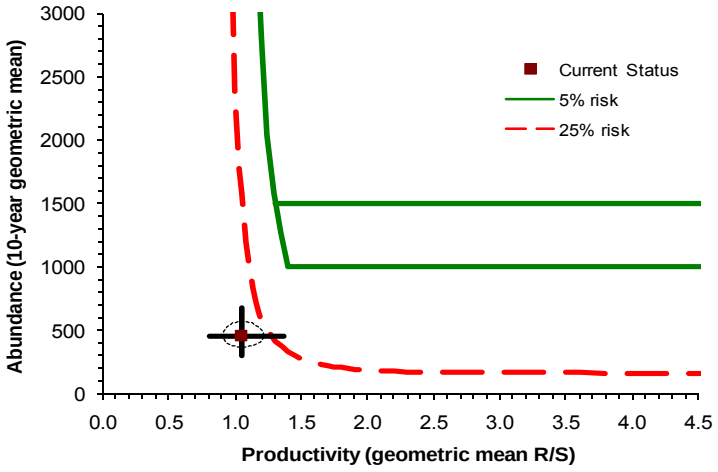


Figure 4. Deschutes River Westside summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

rate metric (λ) with no adjustment for relative hatchery-origin spawner effectiveness (Table 2). The pattern in returns from 1991 through 2005 is similar to the pattern for several other Mid-Columbia DPS steelhead populations, including the Deschutes River Eastside; an increasing trend beginning in 1996 followed by an abrupt decrease to levels observed in the early 1990s. The estimated proportion of hatchery-origin spawners has been relatively constant at 25% over this time period (Table 2). The relative effectiveness of hatchery-origin spawners in contributing to natural production in this population is not known. The estimated population growth rate calculated for this population is sensitive to the input value for relative hatchery effectiveness. Setting the value to 0.0, the opposite extreme from 1.0, results in an estimated annual growth rate of 1.02 (0.58 probability of exceeding 1.0).

Spatial Structure and Diversity

The ICTRT has identified six major spawning areas (MaSAs) and nine minor spawning areas (MiSAs) in the historically accessible habitat within the Deschutes River Westside steelhead population (Figure 5). In the currently accessible habitat there are four MaSAs and seven MiSAs (Figure 6). The Metolius River is identified as a MaSA in the historically accessible habitat; however there is considerable uncertainty regarding the magnitude of historical steelhead production in this river. Recent conclusions reached by Cramer and Beamsderfer (2001) suggest that the primary *O mykiss* life history form in the Metolius River was resident and it is likely that little steelhead production occurred. When we conducted the spatial structure/diversity assessment, we did not consider the Metolius River as a MaSA due to the uncertainty in historical use. Current distribution is reduced significantly from the historic distribution as a result of loss of accessibility to the Whychus Creek drainage.Spawning is currently concentrated in the Warm Springs River and Shitike Creek, as well as in the mainstem Deschutes River between Trout Creek and Pelton Reregulation Dam.

Spawners within the Deschutes River Westside population include natural-origin returns, hatchery returns of Deschutes River origin fish produced from Round Butte Hatchery, and out-of-DPS hatchery strays primarily from the Snake River basin. Hatchery-origin fish comprise a significant proportion of the natural spawners in Shitike Creek and the Deschutes River mainstem. Hatchery fish are removed from returns to the Warm Springs River at Warm Springs NFH, which reduces the proportion of naturally spawning hatchery fish in the population.

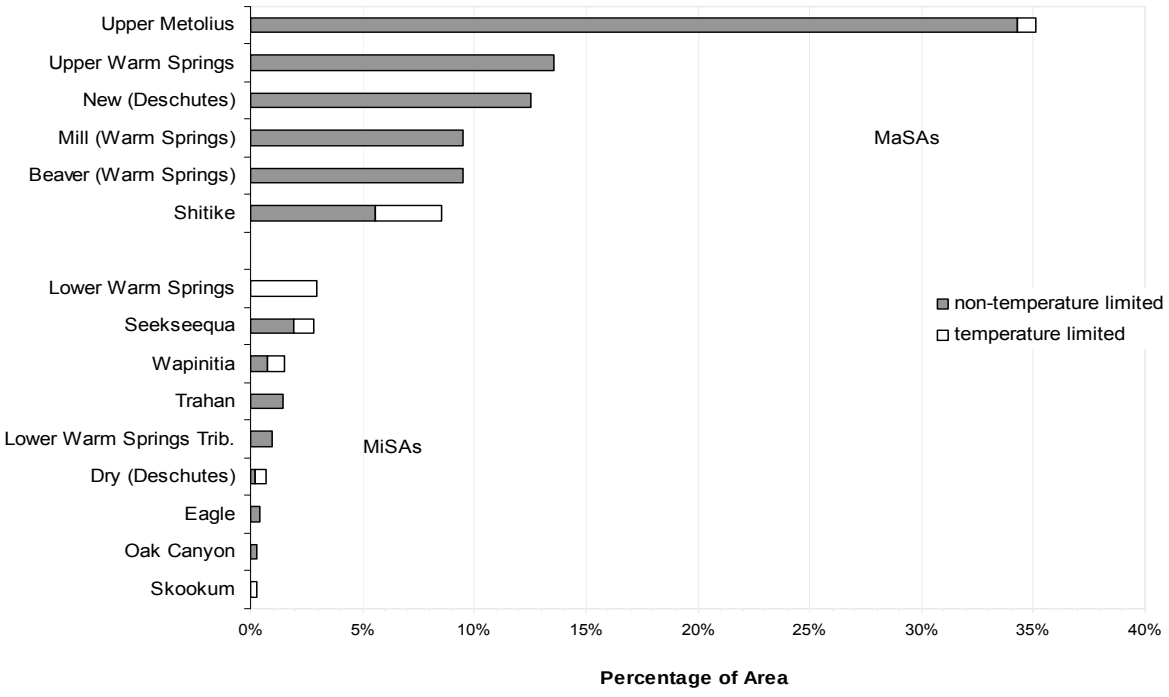


Figure 5. Deschutes River Westside summer steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs). White bars represent current temperature limited areas that could potentially have had historical temperature limitations. This figure is based on *historically* accessible areas within the population.

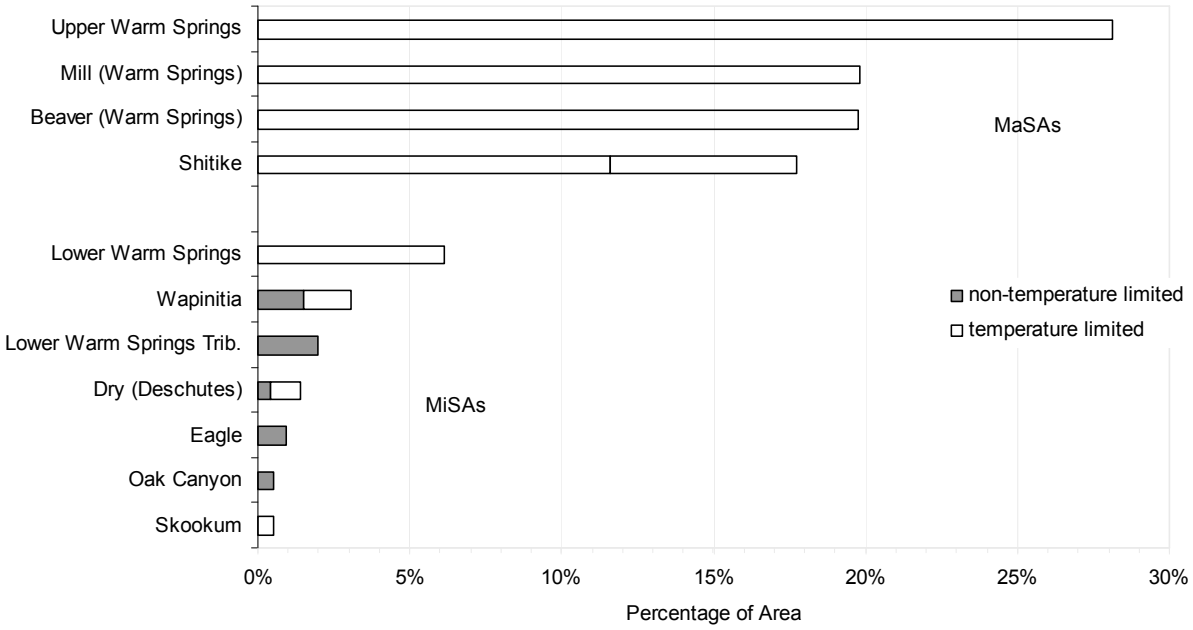


Figure 6. Deschutes River Westside summer steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs). White bars represent current temperature limited areas that could potentially have had historical temperature limitations. This figure is based on *currently* accessible areas within the population.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Deschutes River Westside population has five MaSAs and nine MiSAs distributed in a dendritic pattern. The historic primary production areas include the Warm Springs River, Shitike Creek, Whychus Creek, and the Deschutes River mainstem. Based on the Oregon Department of Fish and Wildlife (ODFW) current spawner distribution database, four of the five historic MaSAs are currently occupied and four of the nine MiSAs are occupied. The Deschutes River Westside population is rated at **very low risk** for this metric.

A.I.b. Spatial extent or range of population

The current spawner distribution is reduced substantially from the historic intrinsic distribution. One of the five historic MaSAs (Whychus) is currently unoccupied. In addition, only four of the nine MiSAs are occupied (Figures 7 and 8). The population is rated at **low risk** because 80% of the MaSAs are occupied. There are index spawning surveys conducted in the Warm Springs River drainage and the Shitike Creek drainage. Results of these surveys will be evaluated for future viability assessments.

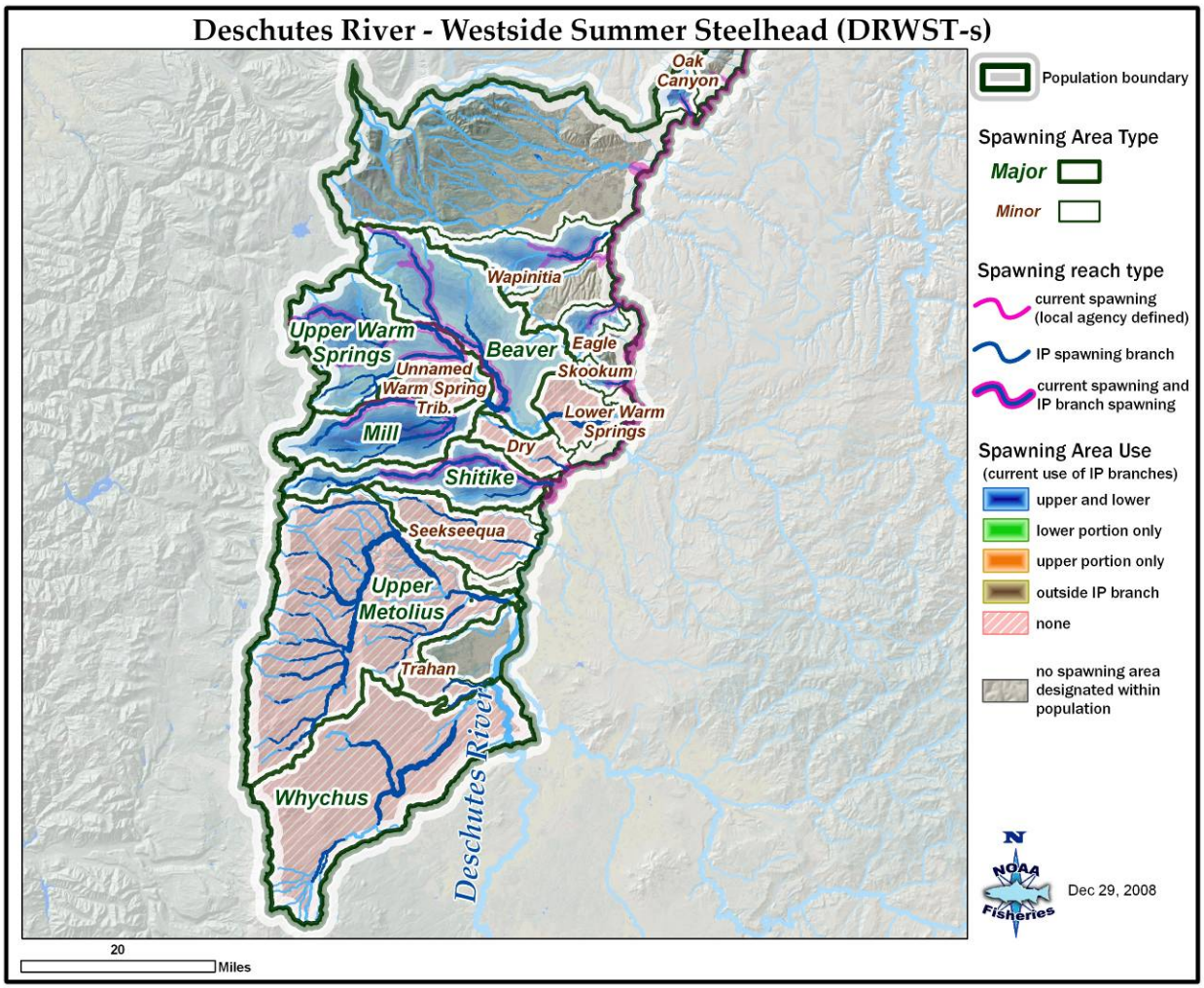


Figure 7. Deschutes River Westside summer steelhead population current spawning distribution and spawning area occupancy designations. This figure is based on currently accessible areas.

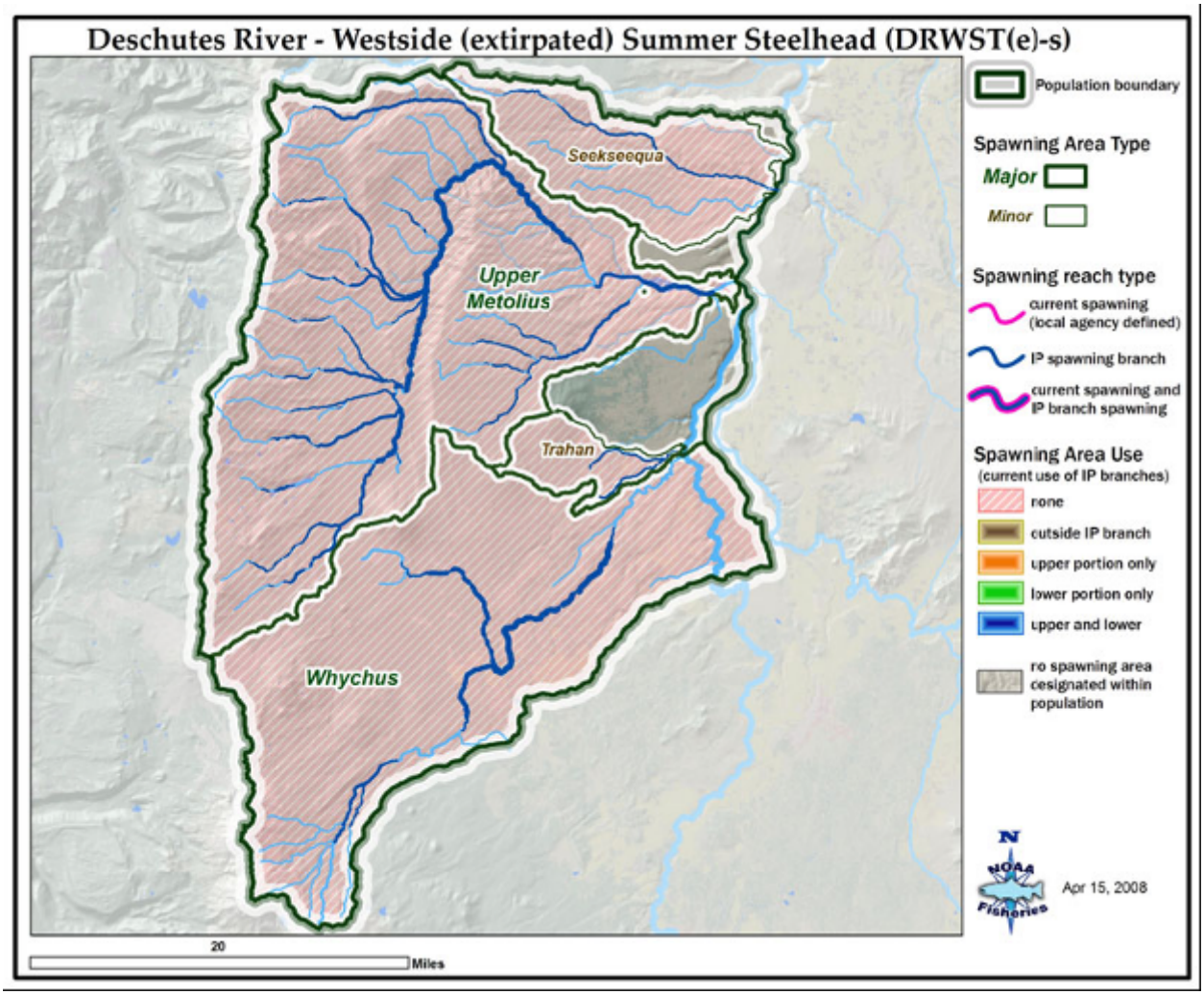


Figure 8. Deschutes River Westside summer steelhead population current spawning distribution and spawning area occupancy designations. This figure is based on historically accessible areas.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There has been a substantial change in gaps between, and continuity within, the spawning areas in the Deschutes River Westside population. The loss of occupancy in the Whychus MaSA has resulted in loss of production in the entire upper area of the population. The population is rated at **moderate risk** for this metric.

B.1.a. Major life history strategies

There are limited data to allow any direct comparisons of historic and current major life history strategies. Current habitat conditions are such that the potential for diverse juvenile life history patterns, such as movement between tributary and mainstem, as well as tributary and mainstem rearing, are possible. The population demonstrates multiple ages of smolt migration and ocean residence time. It does not appear likely that any loss in variability or change in major life

history strategies has occurred for this population. Thus, the population rated at **very low risk** for this metric.

B.1.b. Phenotypic variation

We have no direct observations to assess loss or substantial changes in phenotypic traits, therefore we must infer from habitat conditions. However, there does not appear to be the level of habitat changes within the basin that would result in loss of any major traits or substantial shifts in the mean of multiple traits. It is likely that flow and temperature changes in the mainstem Columbia River, as well as temperature changes within the Deschutes River subbasin, have influenced adult migration timing as well as smolt migration timing to a small degree. Thus, we have rated the population at **low risk** for this metric.

B.1.c. Genetic variation

There are only a few samples available from the Deschutes River Westside population, and those that are available are from a small tributary, Nena Creek. These samples show similarity to both the Deschutes River Eastside population samples and to out-of-population hatchery samples. Primarily on the basis of limited information and apparent similarity to the out-of-population hatchery samples, we have rated the population at **moderate risk** for this metric. Additional tissue samples have been collected and will be analyzed in the near future. The genetics variation metric will be reassessed for this population following the completion of analyses of the recent samples.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners*: A significant number of out-of-DPS strays spawn naturally in the Deschutes River Westside population. Estimates of strays are derived from stray hatchery proportions and stray origin data collected at the Warm Springs NFH trap and expanded to unsampled areas in the population. Hatchery fish are removed at the Warm Springs NFH, thus the overall hatchery proportion in the population is less than the proportion observed at Warm Springs NFH. The majority of stray hatchery fish at Warm Springs NFH are out-of-DPS strays. We estimated that hatchery strays have comprised 18% of the natural spawners in the population since 1978. Of the 18%, about 15.2% were estimated as out-of-DPS strays, primarily from the Snake River basin. We were unable to acquire stray origin data for the most recent years, thus we will update the risk rating when the data are received. Given the high proportion and the length of time that out-of-DPS hatchery strays have been present in this population, the rating is **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS*: There have been few out-of-MPG within-DPS strays recovered in the Deschutes River. The only source for this type of stray fish is from the Umatilla Hatchery program. This metric rated at **low risk** due to the low proportion of strays.

(3) *Out-of-population spawners from within the MPG*: There have been no observed strays originating from hatchery programs operated outside the Deschutes River subbasin but within the MPG. The rating is **very low risk**.

(4) *Within-population hatchery spawners:* The Round Butte Hatchery program operates as a harvest augmentation program within the Deschutes River subbasin and does not use best management practices as described for supplementation programs. Round Butte Hatchery fish are present in the naturally spawning population at low levels with an average of 2.8% since 1978. We have rated the metric at **moderate risk** because of the low proportion of hatchery fish in the natural spawning population.

The overall spawner composition rating is **high risk** due to the high proportion of out-of-DPS strays that spawn naturally in this population.

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution within historically accessible habitat encompassed seven ecoregions (Figures 9 and 10), of which four accounted for 10% or more of the distribution (Table 3). There has been no substantial shift in ecoregion distribution from the historic intrinsic to the current distribution (Table 3). The population rated as **very low risk** because there are four ecoregions with no substantial change in proportional distribution.

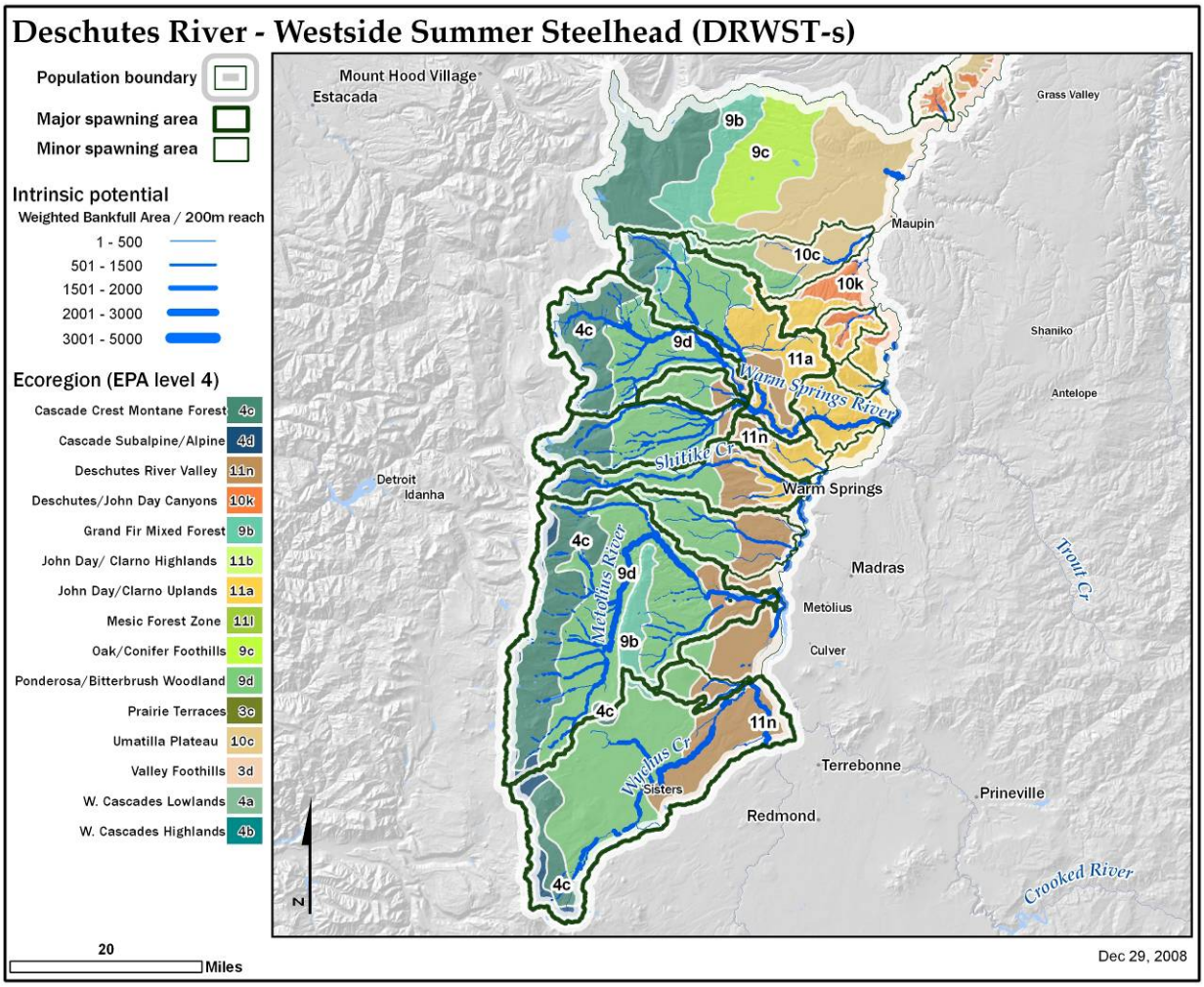


Figure 9. Deschutes River Westside summer steelhead population spawning distribution across EPA level IV ecoregions. This figure is based on currently accessible areas.

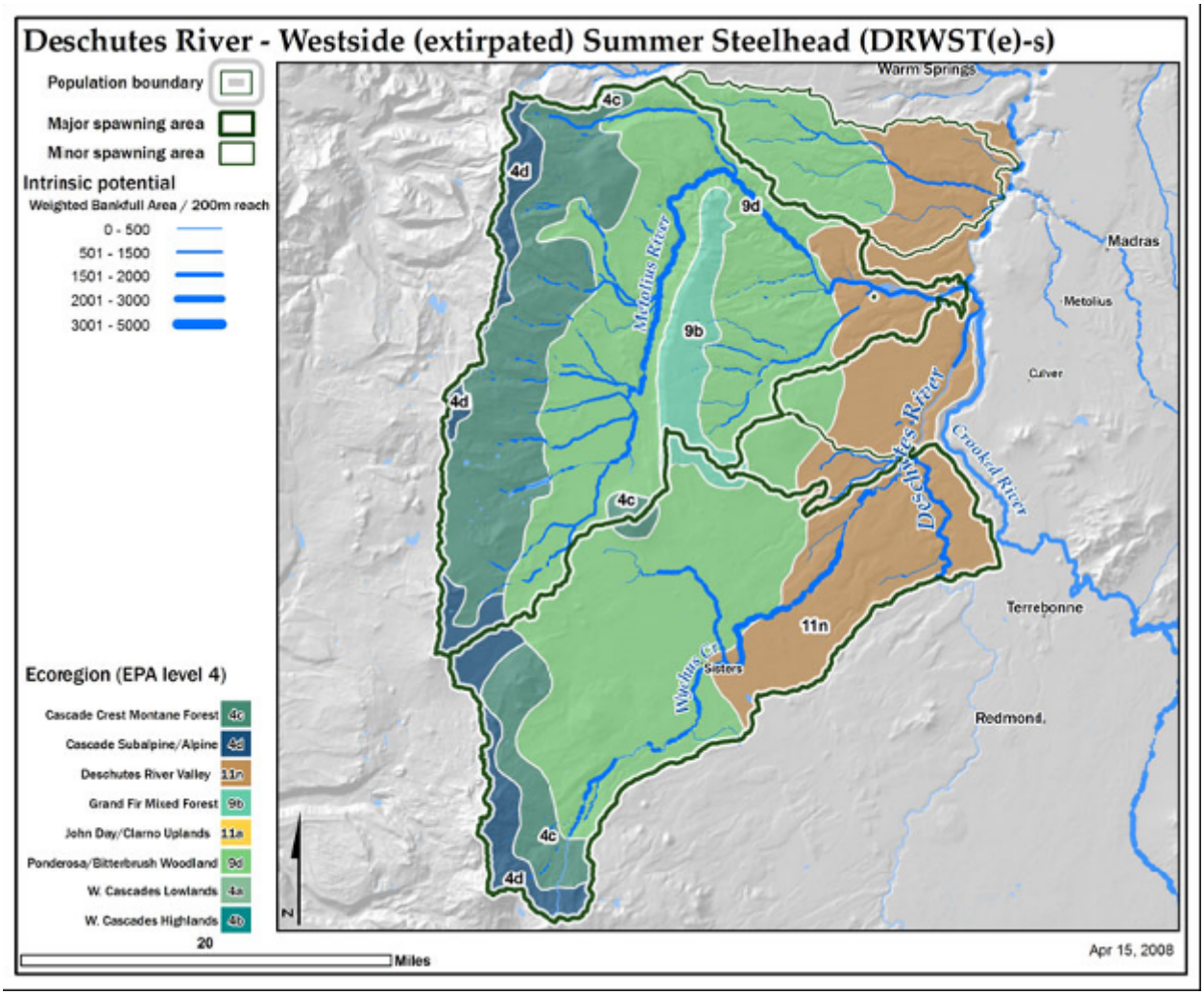


Figure 10. Deschutes River Westside summer steelhead population spawning distribution across EPA level IV ecoregions. This figure is based on historically accessible areas.

Table 3. Deschutes River Westside summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of *historical* spawning area (non-temp. limited) ALL AREAS	% of *currently* occupied spawning area (non-temp. limited) ALL AREAS	% of *historical* spawning area (non-temp. limited) CURRENTLY OCC. AREAS	% of *currently* occupied spawning area (non-temp. limited) CURRENTLY OCC. AREAS
Umatilla Plateau	1.7	4.0	3.0	4.0
Deschutes/John Day Canyons	10.9	27.4	19.6	27.4
John Day / Clarno Uplands	13.0	19.3	23.4	19.3
Deschutes River Valley	18.3	7.3	7.1	7.3
Cascade Crest Montane Forest	8.2	4.7	10.1	4.7
Grand Fir Mixed Forest	0.3	0.5	0.6	0.5
Ponderosa Pine / Bitterbrush Woodland	47.6	36.8	36.1	36.8

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes two dams in its seaward and spawning migrations, thus impacts on this population are relatively low. No traits are selectively affected by hydropower activity to the degree that they raise the risk level for this population. The hydropower rating is **low risk** for all traits.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is no selective impact of the recreational fishery. No phenotypic traits appear to be at risk as a result of harvest activity and the rating is **low risk** for all traits.

Hatcheries: There is a hatchery program operated within this population. Hatchery broodstock are collected at Pelton Dam and no natural-origin fish are collected. Broodstock are collected in a manner which results in no selective impact for any adult phenotypic traits. The population is rated at **very low risk** of selective hatchery actions for all traits.

Habitat: Altered flow profiles and increased temperatures in tributary spawning and rearing areas, which have been in place for many generations and are ongoing, likely impose some selection on juvenile and adult migration timing, as well as spawn timing. However, the magnitude of selective mortality is likely negligible; therefore the habitat rating for all traits is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food

availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selection is **low risk**.

No single trait has a moderate risk rating for any selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** for the Deschutes River Westside population (Table 4). The population rates at moderate risk for one of the spatial distribution metrics (Goal A: **low risk** overall) because the current distribution is substantially reduced from the historic intrinsic distribution due to blocked passages to areas above the Pelton-Round Butte Complex. Ratings for two diversity metrics resulted in a **moderate risk** rating for Goal B (maintaining natural patterns of variation). Genetic variation rated moderate due to limited data and the lack of differentiation between the Deschutes River samples and outside-basin hatchery samples. Samples collected in 2005-2006 will better inform the risk associated with genetic variation. The proportion of out-of-DPS hatchery strays resulted in a high risk rating for spawner composition. Most of these strays originate from the Snake River basin.

Table 4. Deschutes River Westside summer steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Low Risk
(Mean = 1)</td><td rowspan="3">Low Risk
(Mean = 1)</td><td rowspan="15">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>A.1.c</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Moderate Risk (0)</td><td rowspan="10">Moderate Risk (0)</td></tr>
<tr><td>B.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.c</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>L (1)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(4)</td><td>M (0)</td></tr>
<tr><td>B.3.a</td><td>VL (2)</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The Deschutes River Westside steelhead population does not currently meet the ICTRT recommended viability criteria and the overall viability rating is considered **HIGH RISK** (Figure 11). Overall abundance and productivity is rated at **High Risk.** The 10-year geometric mean abundance of natural-origin spawners is 456, which is only 46% of the minimum abundance threshold of 1,000. The 20-year geometric mean productivity (1.05 R/S; Table 6) is below the viability minimum of 1.35 R/S required for an intermediate sized population. A substantial increase in productivity will be required to raise the productivity value to the low risk level. The overall spatial structure and diversity rating is at **Moderate Risk**. The genetics information that is currently being collected will better inform the genetics variation risk level in the future. A reduction in the proportion of naturally spawning out-of-DPS hatchery strays will be needed to reduce the risk rating for the spawner composition metric.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M**	**HR**
	High (>25%)	**HR**	**HR**	**HR** Deschutes River Westside	**HR**

Figure 11. Deschutes River Westside summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – high risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Deschutes River Westside Summer Steelhead Population

Data type: Expansions from single pass surveys, Warm Springs weir count. Annual index area counts expanded to total population abundances using ratio of total to index area weighted intrinsic habitat (ICTRT 2007 Appendix C). Assumed 2.1 fish per redd.

SAR: Mid-Columbia steelhead composite series (see *Methods* section).

Table 5. Deschutes River Westside summer steelhead population abundance and productivity data used for curve fits and R/S analysis. Bolded values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1980	**436**	**0.94**	**410**	**683**	**1.57**	**0.50**	**345**	**0.79**
1981	**577**	**0.96**	**556**	**804**	**1.39**	**0.68**	**549**	**0.95**
1982	839	0.97	816	789	0.94	0.46	360	0.43
1983	**362**	**0.93**	**337**	**864**	**2.39**	**0.52**	**453**	**1.25**
1984	**701**	**0.88**	**616**	**626**	**0.89**	**0.65**	**405**	**0.58**
1985	929	0.95	882	461	0.50	0.46	212	0.23
1986	**711**	**0.94**	**667**	**373**	**0.52**	**0.94**	**351**	**0.49**
1987	1198	0.86	1026	289	0.24	2.18	629	0.52
1988	898	0.76	683	280	0.31	0.99	277	0.31
1989	**513**	**0.91**	**469**	**163**	**0.32**	**0.96**	**156**	**0.31**
1990	**486**	**0.90**	**435**	**185**	**0.38**	**2.83**	**523**	**1.08**
1991	**299**	**0.80**	**240**	**163**	**0.55**	**2.33**	**381**	**1.27**
1992	**525**	**0.72**	**380**	**189**	**0.36**	**1.88**	**355**	**0.68**
1993	**163**	**0.70**	**114**	**317**	**1.95**	**1.18**	**374**	**2.30**
1994	**284**	**0.73**	**206**	**351**	**1.24**	**1.07**	**375**	**1.32**
1995	**249**	**0.68**	**170**	**378**	**1.52**	**1.23**	**463**	**1.86**
1996	**154**	**0.70**	**108**	**573**	**3.72**	**1.03**	**591**	**3.84**
1997	**417**	**0.75**	**314**	**818**	**1.96**	**0.76**	**624**	**1.50**
1998	**648**	**0.57**	**370**	**1005**	**1.55**	**0.49**	**493**	**0.76**
1999	**452**	**0.64**	**290**	**968**	**2.14**	**0.52**	**501**	**1.11**
2000	653	0.71	464					
2001	914	0.83	760					
2002	1226	0.77	944					
2003	1548	0.83	1283					
2004	611	0.79	482					
2005	594	0.88	520					

Table 6. Deschutes River Westside summer steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures						Lambda measures		Abundance
	Not adjusted			SAR adjusted			Not adjusted		
delimited	median	75% lg thresh	75% int thresh	median	75% lg thresh	75% int thresh	1988-1999	1980-1999	Nat. origin geomean
Point Est.	1.46	0.99	1.11	1.48	0.87	1.05	1.04	1.03	456
Std. Err.	0.22	0.18	0.19	0.14	0.17	0.15	0.11	0.12	0.22
count	10	19	16	10	19	16	12	20	10

Table 7. Deschutes River Westside summer steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	0.92	0.16	n/a	n/a	0.34	0.67	52.1	0.84	0.13	n/a	n/a	0.38	0.49	47.3
Const. Rec	435	59	n/a	n/a	n/a	n/a	41.2	399	31	n/a	n/a	n/a	n/a	18.7
Bev-Holt	16.41	54.61	465	122	0.07	0.90	43.9	50.00	78.66	407	34	0.12	0.11	21.8
Hock-Stk	2.87	0.00	152	0	0.07	0.90	44.0	2.92	16.75	137	785	0.12	0.09	21.5
Ricker	2.59	0.78	0.00191	0.00050	0.12	0.81	44.0	2.70	0.55	0.00215	0.00033	0.16	0.02	27.8

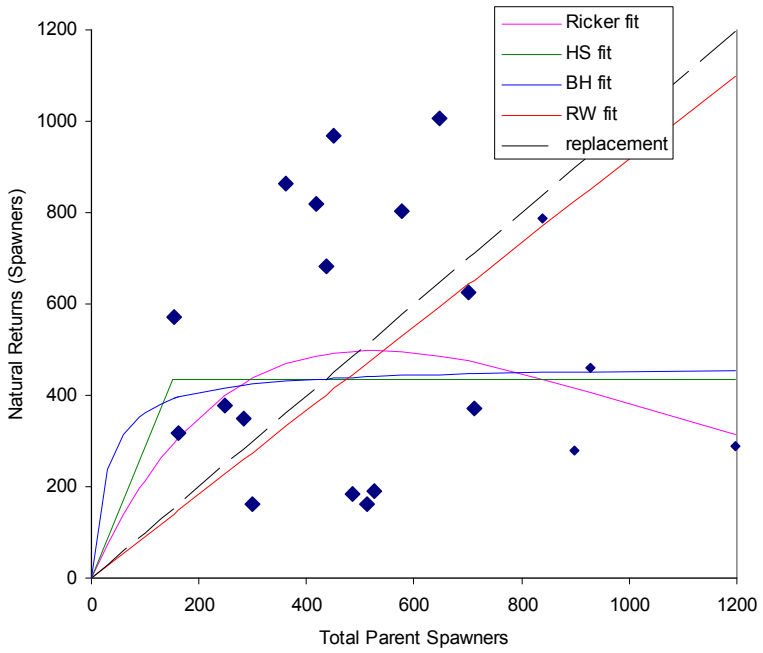


Figure 12. Deschutes River Westside summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

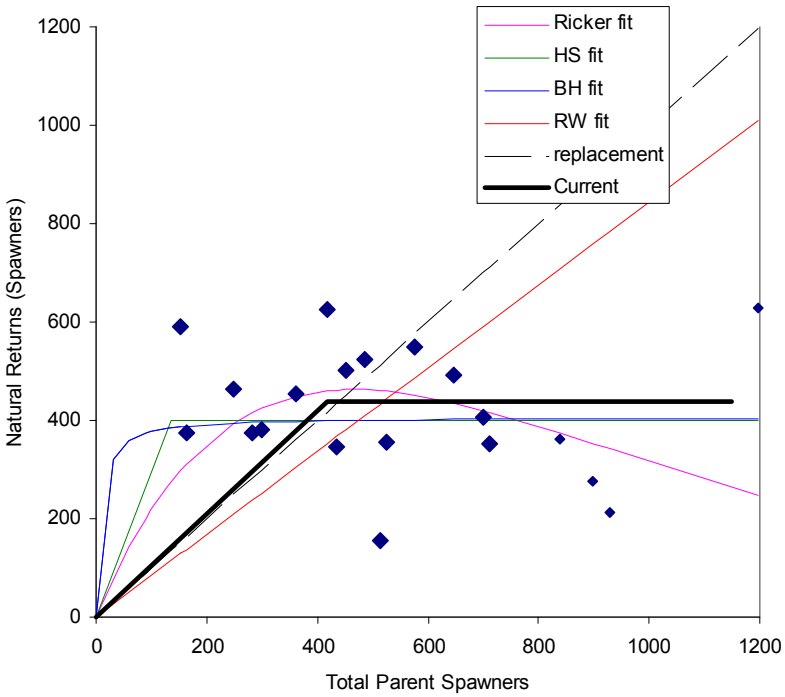


Figure 13. Deschutes River Westside summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Crooked River Summer Steelhead Population

The functionally extirpated Crooked River summer steelhead population (Figure 1), located entirely above the Pelton Reregulation Dam in the Deschutes River subbasin, was historically part of the Cascades Eastern Slope Tributaries MPG within the Mid-Columbia steelhead DPS.

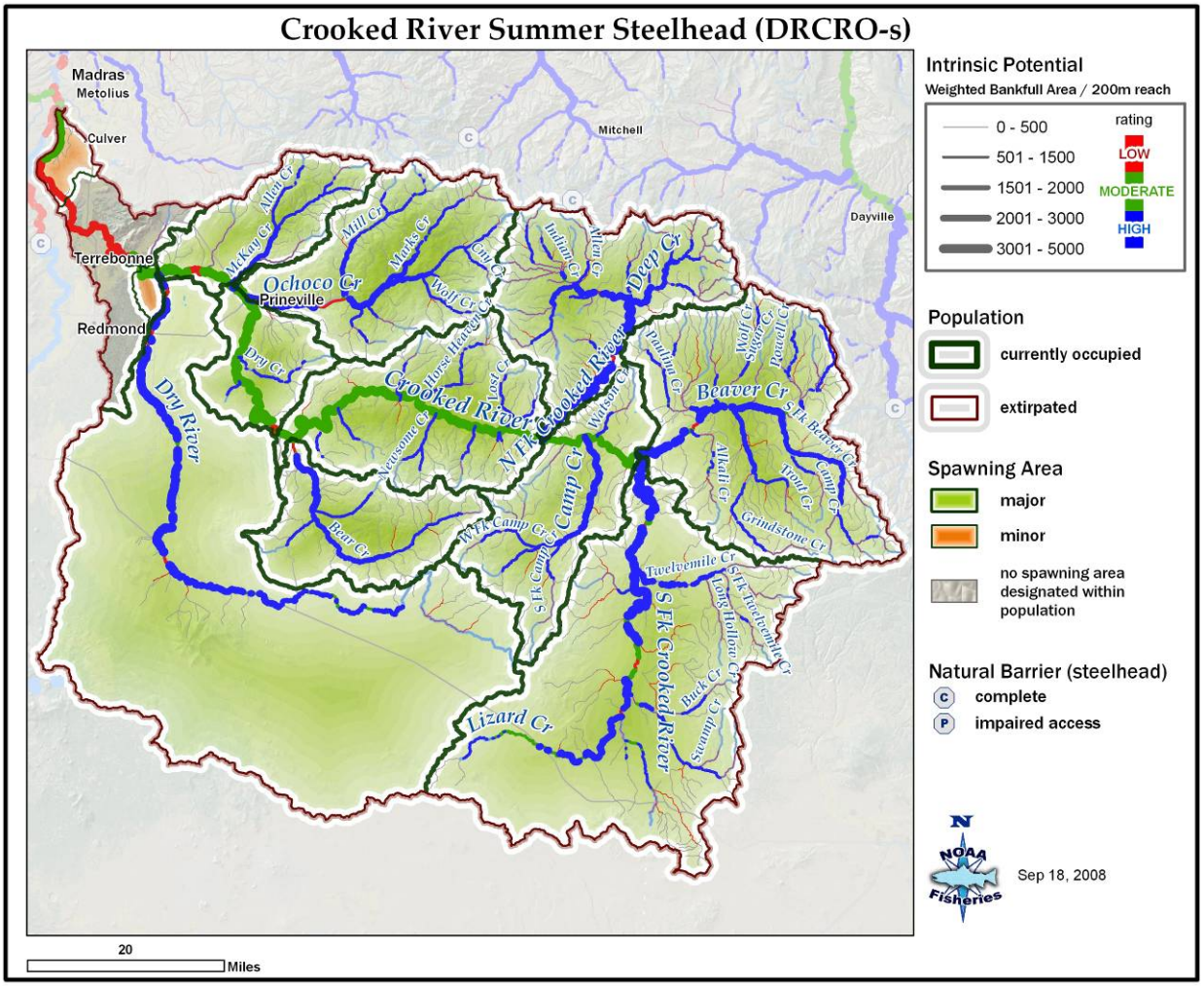


Figure 1. Crooked River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Crooked River population as "very large" in size and complexity (Table 1). A steelhead population classified as very large has a mean minimum abundance threshold of 2,250 natural-origin spawners with sufficient intrinsic productivity (≥ 1.19 recruits per spawner at the abundance threshold level) to achieve a 5% or less risk of extinction over a 100-year timeframe. In order for the Crooked River population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 14 recruits per spawner at the minimum abundance threshold.

Table 1. Crooked River summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	11,832
Stream lengths km (total) [a]	2054
Stream lengths km (below natural barriers) [a]	2046
Branched stream area weighted by intrinsic potential (km^2)	9.855
Branched stream area km^2 (weighted and temp. limited) [b]	9.855
Total stream area weighted by intrinsic potential (km^2)	11.358
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	11.358
Size / Complexity category	Very Large / "B" (dendritic structure)
Number of major spawning areas (MaSA)	10
Number of minor spawning areas (MiSA)	2

a. All stream segments ≥3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

The Crooked River steelhead population is currently extirpated. Steelhead distribution was restricted in Crooked River by construction of Ochoco Dam at RM 10 in 1921 and further by Bowman Dam (RM 70) constructed in 1961. Access to habitat above RM 100 on the mainstem Deschutes River was blocked entirely by 1968 due to inadequate passage at the Pelton and Round Butte dams, thus terminating access to the Crooked River drainage.

Spatial Structure and Diversity

The ICTRT has identified ten major spawning areas (MaSAs) and two minor spawning areas (MiSAs) within the Crooked River steelhead population (Figure 3.1.7–2). The population boundaries are completely above the Pelton Reregulation Dam and, therefore, all areas are currently inaccessible.

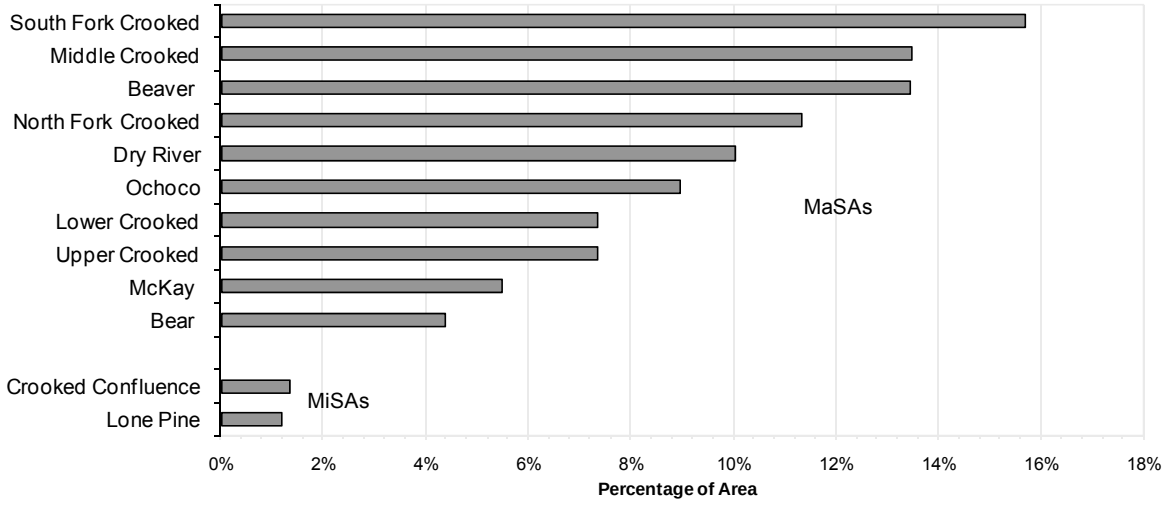


Figure 3.1.7– 2. Crooked River summer steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor (MiSAs) spawning areas. There are no areas in this population that could potentially have had historical temperature limitations.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Crooked River population has ten MaSAs and two MiSAs distributed in a dendritic pattern. All areas within this population have been extirpated due to the Pelton Reregulation Dam. Reintroduction of steelhead into the Crooked River subbasin is currently being planned.

A.l.b. Spatial extent or range of population

There is no current spawner distribution. All areas above the Pelton Reregulation Dam, including the Crooked River population, have been extirpated (Figure 3).

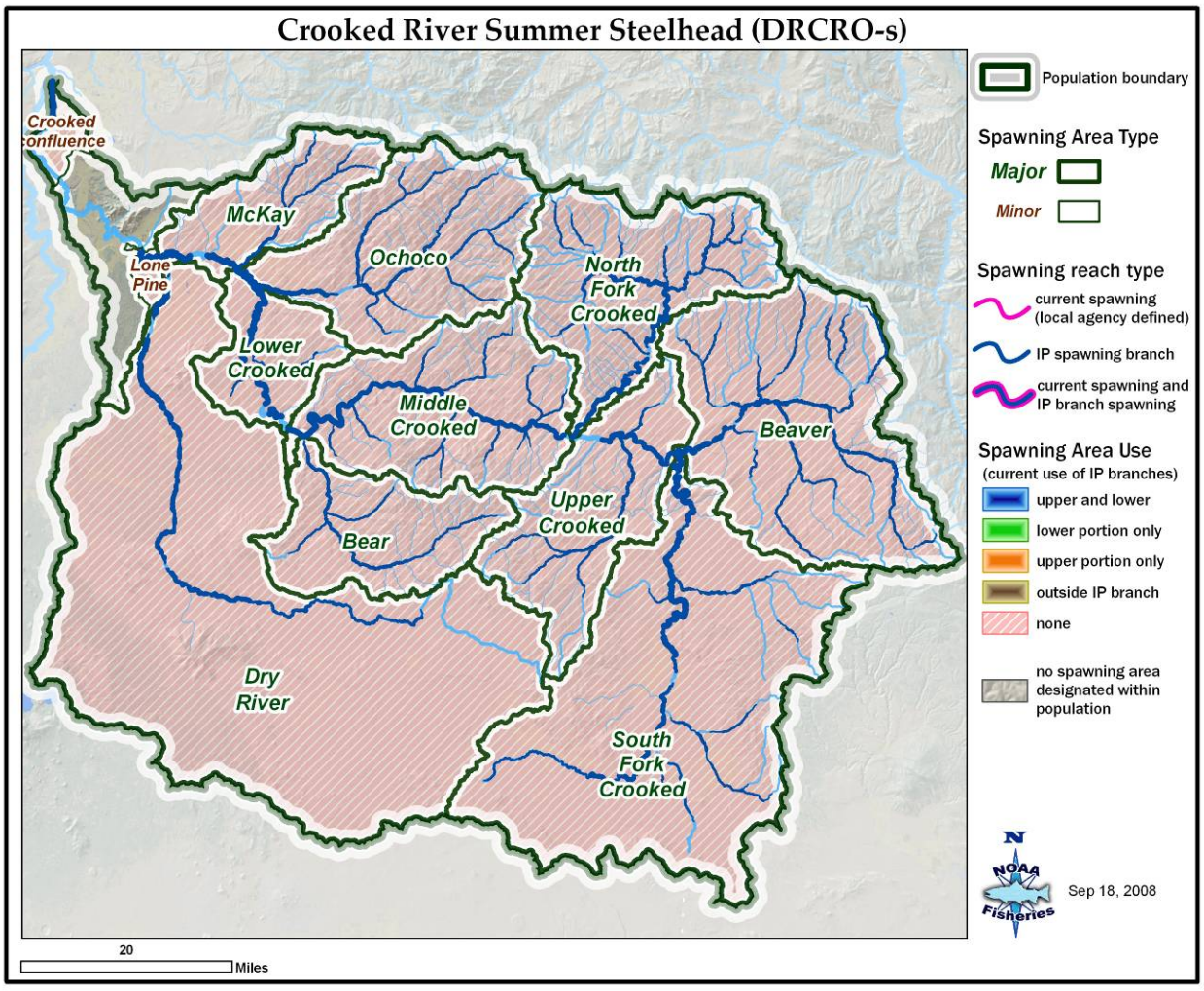


Figure 3. Crooked River summer steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

This population is functionally extirpated and is therefore not rated.

B.1.a. Major life history strategies

There are no data to allow any direct analyses of historic major life history patterns. This population is functionally extirpated and is therefore not rated.

B.1.b. Phenotypic variation

We have no direct observations to assess historic phenotypic traits. This population is functionally extirpated and is therefore not rated.

B.1.c. Genetic variation

There are no genetics data for the Crooked River population. This population is functionally extirpated and is therefore not rated.

B.2.a. Spawner composition

This population is functionally extirpated and is therefore not rated.

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution encompassed eight ecoregions, of which three accounted for greater than 10% of the distribution (Figure 4). The Crooked River steelhead population is extirpated and therefore no ecoregions are currently occupied.

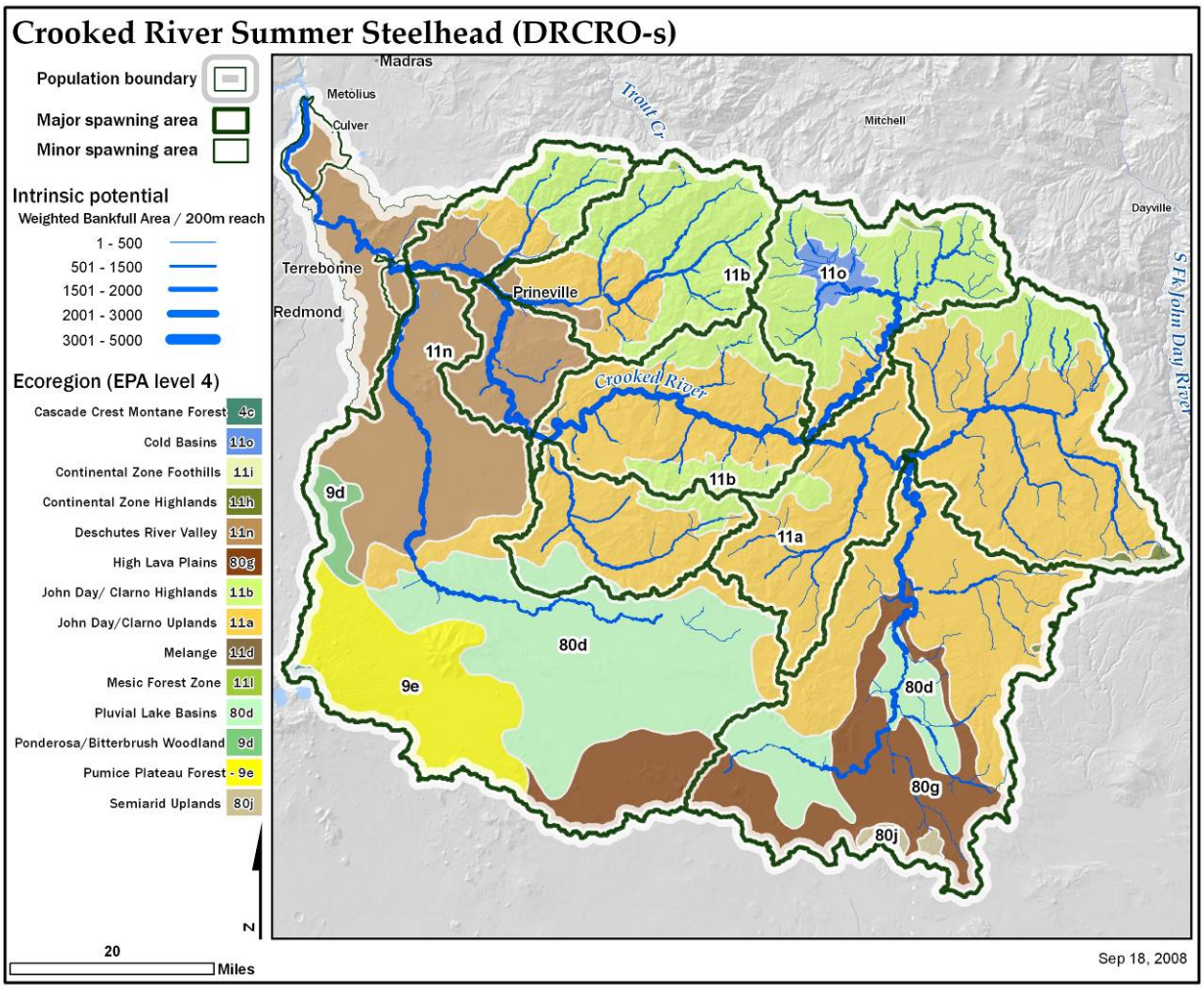


Figure 4. Crooked River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 2. Crooked River summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
John Day Clarno Uplands	46.7	0
John Day Clarno Highlands	13.2	0
Continental Zone Highlands	0.03	0
Mesic Forest Zone	0.04	0
Deschutes River Valley	22.53	0
Cold Basins	2.11	0
Pluvial Lake Basins	7.45	0
High Lava Plains	4.98	0

B.4.a. Selective change in natural processes or selective impacts

This population is functionally extirpated and is therefore not rated.

Spatial Structure and Diversity Summary

The Crooked River summer steelhead population is not rated for spatial structure and diversity since it is considered to be functionally extirpated.

Overall Viability Rating

The Crooked River summer steelhead population does not have an overall viability rating since it is considered to be functionally extirpated.

Lower Mainstem John Day River Summer Steelhead Population

The Lower Mainstem John Day River summer steelhead population (Figure 1) is one of five populations in the John Day River MPG within the Mid-Columbia steelhead DPS. All five populations in the John Day River MPG are summer run.

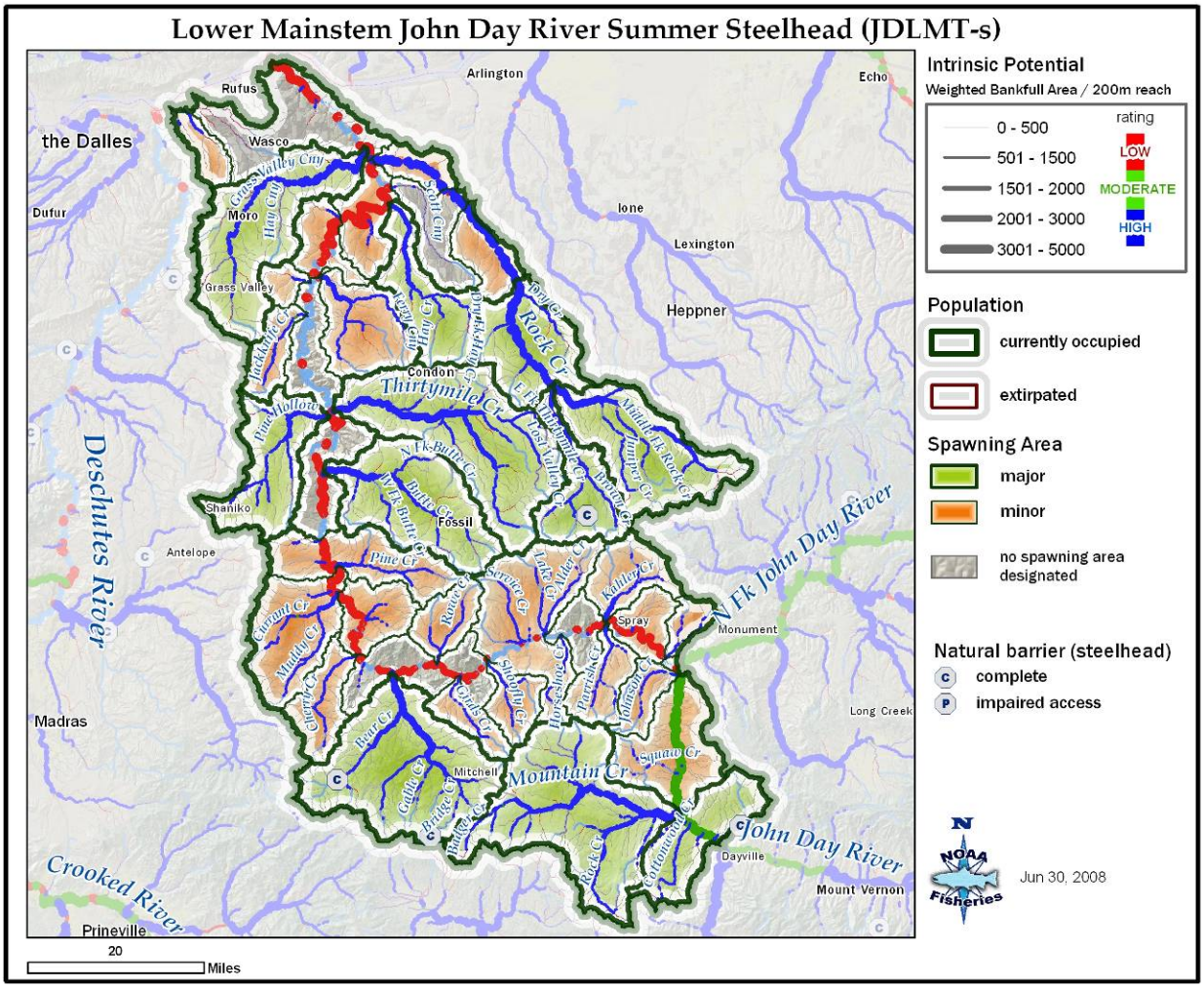


Figure 1. Lower Mainstem John Day River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Lower Mainstem John Day River population as "very large" in size and complexity (Table 1) based on historical habitat potential (ICTRT 2007). A steelhead population classified as very large has a minimum abundance threshold criteria of 2,250 natural-origin spawners with sufficient intrinsic productivity (≥ 1.19 recruits per spawner at the threshold abundance level) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the Lower Mainstem population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.41 recruits per spawner at the minimum abundance threshold.

Table 1. Lower Mainstem John Day River summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	9,857
Stream lengths km (total) [a]	2,455
Stream lengths km (below natural barriers) [a]	2,411
Branched stream area weighted by intrinsic potential (km^2)	6.778
Branched stream area km^2 (weighted and temp. limited) [b]	5.065
Total stream area weighted by intrinsic potential (km^2)	11.754
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	6.433
Size / Complexity category	Very Large / "B" (dendritic structure)
Number of major spawning areas (MaSAs)	11
Number of minor spawning areas (MiSAs)	19

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

Current (1965-2005) total abundance (number of adult spawners in natural production areas) for this population has ranged from 111 in 1979 to 10,557 in 1987 (Figure 2). Abundance estimates are based on expanded redd counts. Index surveys of steelhead redds from the Oregon Department of Fish and Wildlife (ODFW), John Day District, were used for the historical dataset. We used index surveys that showed relatively consistent visitation through all years. Survey data from Bear, Kahler, Parrish, Pine, and Thirtymile creeks were used in the analyses. The current spawning distribution was used for the miles of available habitat within each population's range. The index redd densities were then multiplied by a correction factor to estimate the annual redd densities for the entire spawning distribution, based on the ratio of index redd densities to redd densities in 2004-2005 derived from the Environmental Monitoring and Assessment Program (EMAP); the ratio was consistent for these years (0.36, 0.35). The estimated redd density for the entire spawning area (0.355 x index density) was multiplied by the total miles of spawning habitat currently utilized. Total annual redds were converted to fish by multiplying the total annual number of redds by the number of fish per redd. Fish per redd ratios were developed from survey data on Deer Creek in the Grande Ronde River basin and are an average from four years of data from complete and repeated redd surveys (censuses) above a weir where we have a complete fish count; the calculated average fish per redd estimate was 2.1.

The hatchery-origin/natural-origin composition of spawners was computed separately for the Lower Mainstem John Day River and combined for all other populations in the MPG. Data included observations of positively identified fin-clipped spawners (1992-present) from spawning surveys. Evidence from the Deschutes River indicates that hatchery straying was substantially lower before 1992; because the source of strays in the John Day River basin is the same as the Deschutes River, we assumed a similar trend. No other data are available for earlier years so the hatchery fraction was set at zero. Age composition was derived from scale readings of creel sampled unmarked fish collected during the 1980s above Tumwater Falls.

Recent natural spawners include returns originating from naturally spawning parents and a small fraction of strays from Snake and Columbia River hatchery programs. Spawners originating from naturally spawning parents have comprised an average of 92% of the spawners since hatchery strays began being documented in 1992. Since that time, the percentage of natural spawners has ranged from 82%-99%.

Abundance in recent years has been highly variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 1,800 (Table 2). During the period 1975-1997, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Lower Mainstem population ranged from 0.14 in 1987 to 17.5 in 1979. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 19-year (1980-1998) geometric mean productivity was 2.99 R/S, adjusted for SAR and delimited at 75% (1,688 spawners) of the abundance threshold.

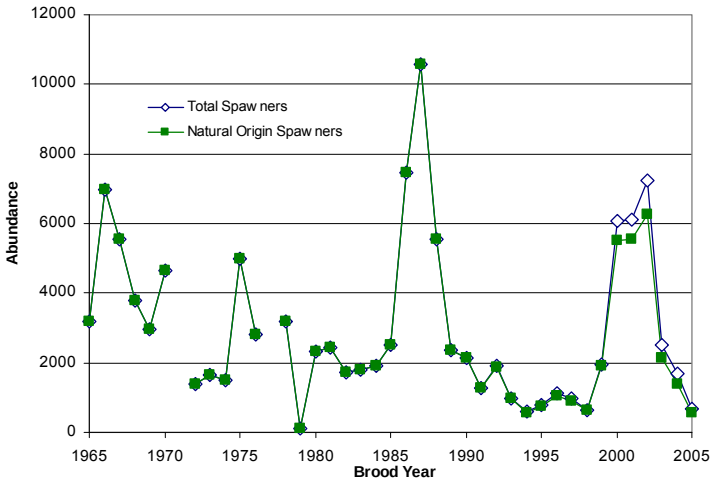


Figure 2. Lower Mainstem John Day River summer steelhead population spawner abundance estimates (1965-2005).

Table 2. Lower Mainstem John Day River summer steelhead population abundance and productivity estimates.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	1,800	(563-6,257)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.90	(0.82-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (19-year R/S, SAR adjusted & delimited) [a]	2.99	(1.91-4.67)	0.24
Productivity (19-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	0.98	(0.94-1.14)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	1.00	(0.71-1.41)	0.50
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.01	(0.71-1.43)	0.53

a. Delimited productivity excludes any recruit/spawner pair where the spawner number >75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Lower Mainstem John Day River population is at **Moderate Risk** based on current abundance and productivity. The productivity is at very low risk because the point estimate is above very low risk and the lower end of the adjusted standard error is above the 5% risk level. The abundance is at moderate risk because it resides between the 5% and 25% risk levels (Figure 3).

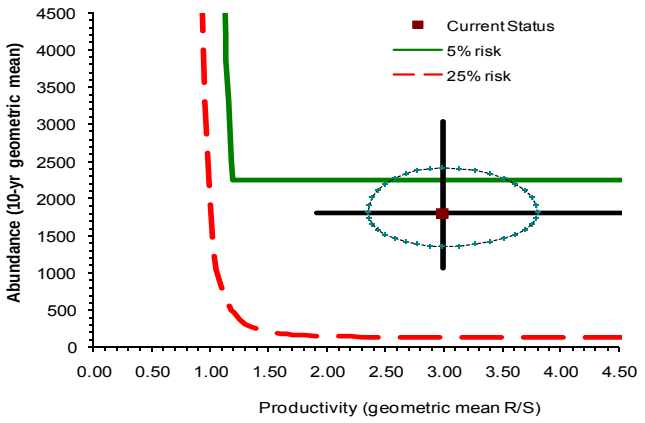


Figure 3. Lower Mainstem John Day River summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

The average trend in natural-origin spawner abundance over the most recent 20 years has been just below 1.0; the

population growth rate metric (λ), calculated with relative hatchery effectiveness set to 1.0, was 1.00 for the same period (Table 2). The pattern in returns from 1991 through 2005 is similar to the pattern for several other Mid-Columbia DPS steelhead populations, including the Deschutes River Eastside—an increasing trend beginning in 1996 followed by an abrupt decrease to levels observed in the early 1990s. The estimated proportion of hatchery-origin spawners has averaged approximately 10% for the period. The relative effectiveness of hatchery-origin spawners in contributing to natural production in this population is not known. Setting the value to 0.0, the opposite extreme from 1.0, results in an estimated annual growth rate of 1.01 (0.53 probability of exceeding 1.0).

Spatial Structure and Diversity

The ICTRT has identified 11 major spawning areas (MaSAs) and 19 minor spawning areas (MiSAs) within the Lower Mainstem John Day River population (Figure 4). Spawning is distributed broadly across the landscape in numerous watersheds that flow into the lower mainstem of the John Day River. Moderately large drainages such as Rock, Thirtymile, Bridge, Service, Mountain and Butte creeks comprise a substantial proportion of the production area. In addition, multiple smaller drainages support production. Spawners within the Lower Mainstem population are predominantly natural-origin; however, outside-DPS hatchery fish, primarily from Snake River stocks, are present in significant proportions in some years.

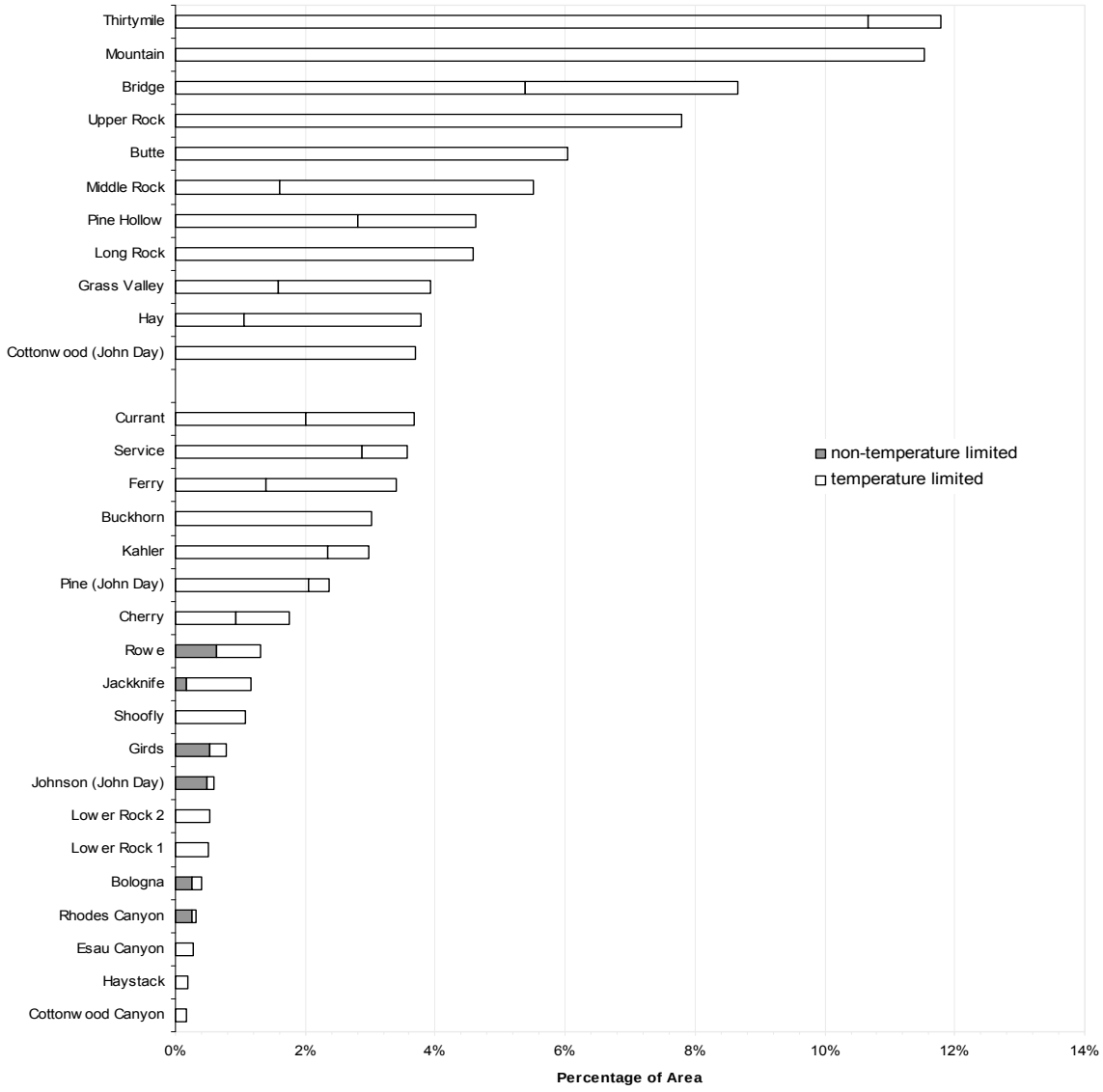


Figure 4. Lower Mainstem John Day River summer steelhead population distribution of intrinsic potential habitat across major and minor spawning areas. White bars represent the area that could potentially have had historical temperature limitations.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Lower Mainstem population has 11 MaSAs and 19 MiSAs distributed in a very complex dendritic pattern. Intrinsic potential is distributed relatively evenly across the 11 MaSAs. Based on the ODFW spawner distribution database all 11 of the MaSAs are currently occupied (except for the upper portion of the Cottonwood MaSA) and 11 of the 19 MiSAs are occupied (Figure 5). A total of 1,197 km of habitat is presently used for spawning. The Lower Mainstem population rates at **very low risk** for this metric.

A.l.b. Spatial extent or range of population

The current spawner distribution closely resembles the intrinsic potential distribution. All of the MaSAs are currently occupied except the upper portion of Cottonwood, and 11 of the 19 MiSAs are also occupied. The unoccupied MiSAs are scattered throughout the population, and, therefore, do not result in a change in extent and range of distribution. The rating is **very low risk**. There are six index spawning survey sites in the Lower Mainstem population.

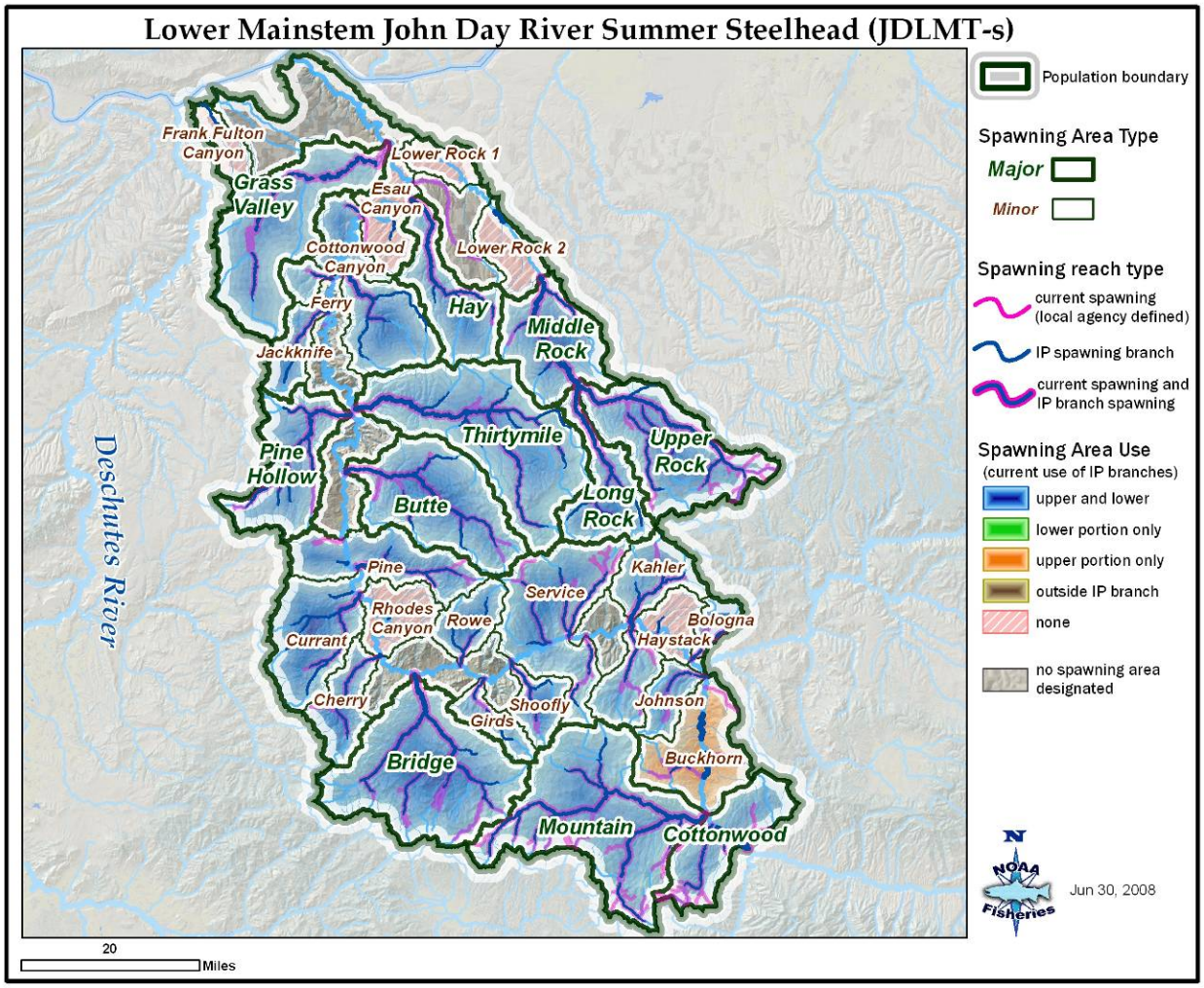


Figure 5. Current spawning distribution and spawning area occupancy designations of the Lower Mainstem John Day River summer steelhead population.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There has not been any significant increase in gaps relative to historic intrinsic distribution. Although 8 of the 19 MiSAs are not currently occupied, the remaining occupied spawning areas (11 MaSAs and 11 MiSAs) provide good continuity between spawning areas throughout the population as well as relatively unchanged gaps. The Lower Mainstem population rating is **very low risk** for this metric.

B.1.a. Major life history strategies

The Lower Mainstem population is an A-run population that migrates to the ocean at multiple ages and returns after spending one or two years in the ocean (based on ages of natural-origin angler caught fish). These life history patterns are consistent with other A-run steelhead. There are limited data available to evaluate changes in life history patterns for this population; thus, they must be inferred based on habitat changes. This population is very large and inhabits a broad geographic area with habitat quality ranging from good to poor. Although current habitat conditions provide opportunity for expression of diverse life history strategies, habitat changes (particularly temperature) have likely reduced movement patterns and summer rearing distribution. This population rates at **moderate risk** for this metric because of the loss of tributary habitat rearing due to flow and temperature.

B.1.b. Phenotypic variation

There are no data to directly assess if any phenotypic traits have been substantially changed or lost, thus, they must inferred from habitat data. We hypothesize that there has been some reduction in variability of traits, such as adult entry and migration timing through the Columbia and John Day rivers, as well as juvenile migration timing. Although the distribution of these types of traits has likely been altered, the magnitude has likely not been substantial. Habitat conditions and absence of significant major phenotypic selective pressures indicate this population is at **low risk**.

B.1.c. Genetic variation

There are limited genetic data for John Day River populations, and no samples have been analyzed for the Lower Mainstem population. The major concern regarding genetic variation within the Lower Mainstem population relates to the spawner composition and potential genetic effects of out-of-DPS hatchery strays. There are no past population bottlenecks or intentional hatchery practices that would influence genetic variation. Due to the high proportion of hatchery strays and the lack of genetic data for this population, we have rated this metric as **moderate risk.** Samples were collected in 2005 and 2006 to provide an assessment of the genetic characteristics of the Lower Mainstem population. These data will allow for a more informed assessment of the genetic variation in the future.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners:* Based on coded wire tags (CWTs) recovered primarily from recreational fisheries, the proportion of out-of-DPS hatchery spawners in the Lower Mainstem John Day River population has ranged from 0.1 in the early 1990s to 0.18 in 2004, with a mean

of 0.07. The trend from the early 1990s to 2005 has shown a consistent increase in hatchery proportion through time. The hatchery fish originate primarily from the Snake River Basin. Due to the combined effects of the high hatchery fraction, the increasing trend through time, and the origin of the strays, this population rates at **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS*: There have been a total of four CWTs recovered from fish in the John Day River from out-of-MPG within-DPS origin. Three originated from the Umatilla Hatchery program and one from the Deschutes Hatchery program. It appears very few within-DPS hatchery fish stray into the John Day River, thus the rating is **low risk** for this metric.

(3) *Out-of-population spawners from within the MPG:* There are no steelhead hatchery programs operated within the John Day River basin; therefore, this metric is rated as **very low risk**.

(4) *Within-population hatchery spawners:* There are no steelhead hatchery programs operated within the John Day River basin; therefore, this metric is rated as **very low risk.**

The overall spawner composition rating is **high risk** due to the high proportion of out-of-DPS strays that potentially spawn in this population**.**

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution of the Lower Mainstem John Day River population encompassed seven ecoregions (Figure 6), although only two had values greater than 10%. There has been little change in distribution among ecoregions and no substantial reductions. All ecoregions that had significant use historically remain in use currently (Table 3). The rating is **low risk** for this metric.

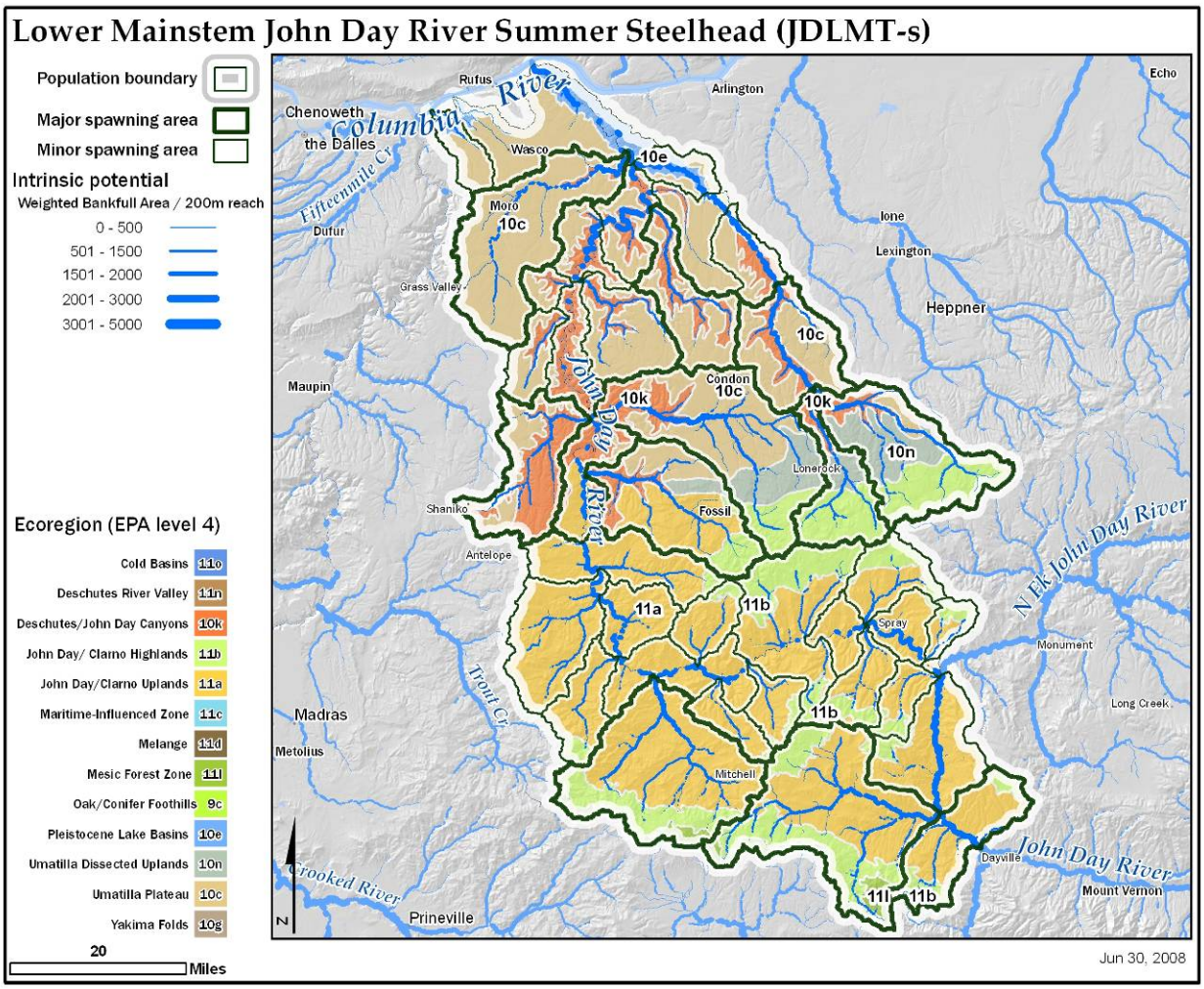


Figure 6. Lower Mainstem John Day River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Proportion of current spawning areas across EPA level IV ecoregions of the Lower Mainstem John Day River summer steelhead population.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Deschutes/John Day Canyons	32.0	35.4
John Day Clarno Highlands	5.2	7.9
John Day Clarno Uplands	46.6	42.7
Mesic Forest Zone	0.2	0.4
Pleistocene Lake Basins	6.1	0.1
Umatilla Dissected Uplands	2.7	4.7
Umatilla Plateau	7.2	8.9

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes three dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Adult migration timing:* The dams create a thermal barrier in the reservoirs that delays and potentially induces some mortality of migrating adults. This barrier is diminished later in the migration season. Because the timing of the barrier varies from year to year and does not develop in some years, and the degree of differential survival is likely low although not well-understood, we rate the selection intensity as low. Heritability of this trait is high; thus, the hydropower rating for this trait is **moderate risk**.

Harvest: Harvest has the potential to affect migration timing, maturation timing, and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts would be negligible. There is very limited tribal harvest of natural-origin fish within the John Day River subbasin. Impacts from the recreational fishery are incidental to the harvest of hatchery-origin fish and are not selective. No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: There are no steelhead hatchery programs operated within the population; therefore, the hatchery rating is **very low risk** for all traits.

Habitat: Altered flow and increased temperatures in spawning, rearing, and the mainstem migration corridor, which have been in place for many generations and are ongoing, likely impose some selection on juvenile and adult migration timing.

> *Adult migration timing:* Low flows in the late summer and early fall in the John Day River likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable, but a negligible proportion of the population is likely subject to these effects. Thus, the impact of habitat changes on this trait is **low risk.**
>
> *Juvenile migration timing:* Late spring and early summer temperatures are elevated relative to historical conditions. There has likely been some affect on juvenile migration timing as late spring and early summer river temperatures can reach stressful levels in some years in the John Day River mainstem. Selection intensity is considered negligible and the heritability of this trait is moderate to low. The impact of habitat changes on this trait is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective

predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

There is only one trait that has a moderate rating for one selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** for the Lower Mainstem John Day River population (Table 4). The rating for Goal A (allowing natural rates and level of spatially mediated processes) was **very low risk**. The current spawner distribution is similar to historic with all MaSAs occupied. The MiSAs that are currently unoccupied have little influence on gaps and continuity, and spawners are spread over a very broad geographic area.

The rating for Goal B (maintaining natural levels of variation) was **moderate risk**. This rating was a result of moderate risk for life history and genetic variation and high risk for spawner composition out-of-DPS hatchery strays. The magnitude and trend in out-of-DPS hatchery strays are of significant concern. Analysis of genetic information will yield considerable insight into the genetic characteristics of this population. The extent of hatchery introgression will be useful information for future spatial structure/diversity risk assessments.

Table 4. Spatial structure and diversity risk rating of the Lower Mainstem John Day River summer steelhead population.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Very Low Risk
(Mean = 2)</td><td rowspan="3">Very Low Risk
(Mean = 2)</td><td rowspan="15">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>A.1.c</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.1.a</td><td>M (0)</td><td>M (0)</td><td rowspan="3">Moderate (0)</td><td rowspan="10">Moderate Risk (0)</td></tr>
<tr><td>B.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.c</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>L (1)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The Lower Mainstem John Day River summer steelhead population does not meet viability criteria. However, the population does meet criteria to be rated as **MAINTAINED** (Figure 7). Overall abundance and productivity is rated at **Moderate Risk.** The 10-year geometric mean abundance of natural-origin spawners is 1,800, which is 80% of the minimum abundance threshold of 2,250. The 19-year geometric mean productivity (2.99 R/S; Table 6) exceeds the minimum required productivity of 1.19 R/S at the abundance threshold. Overall spatial structure and diversity is also rated at **Moderate Risk.** To achieve a viable rating, this population must improve in both abundance/productivity and spatial structure/diversity. Out-of-DPS spawners are the most influential factor on diversity risk. Additional data are needed to better quantify spawner composition to reduce the uncertainty associated with this risk metric.

Abundance/ Productivity Risk	Spatial Structure/Diversity Risk: Very Low	Low	Moderate	High
Very Low (<1%)	HV	HV	V	M
Low (1-5%)	V	V	V	M
Moderate (6 – 25%)	M	M	M Lower Mainstem John Day River	HR
High (>25%)	HR	HR	HR	HR

Figure 7. Lower Mainstem John Day River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells – does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Lower Mainstem John Day River

Data type: Redd count expansion - Index area redd counts expanded to total population estimate by applying ratio of average redd densities (samples across all areas to samples from index reaches) from EMAP surveys. Assumed 2.1 fish per redd.

Smolt-to-Adult Return rate (SAR): Mid-Columbia composite series (see *Methods*).

Table 5. Abundance and productivity data used for curve fits and R/S analysis of the Lower Mainstem John Day River summer steelhead population. Bold values used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1980	2329	1.00	2329	2749	1.18	0.50	1388	0.60
1981	2420	1.00	2420	5525	2.28	0.68	3773	1.56
1982	1714	1.00	1714	8654	5.05	0.46	3955	2.31
1983	1815	1.00	1815	7493	4.13	0.52	3924	2.16
1984	1916	1.00	1916	3776	1.97	0.65	2442	1.27
1985	2521	1.00	2521	2154	0.85	0.46	989	0.39
1986	7468	1.00	7468	1716	0.23	0.94	1618	0.22
1987	10557	1.00	10557	1515	0.14	2.18	3297	0.31
1988	5546	1.00	5546	1348	0.24	0.99	1335	0.24
1989	2366	1.00	2366	774	0.33	0.96	744	0.31
1990	2133	1.00	2133	703	0.33	2.83	1990	0.93
1991	**1264**	**1.00**	**1264**	**898**	**0.71**	**2.33**	**2096**	**1.66**
1992	1917	0.99	1889	945	0.49	1.88	1777	0.93
1993	**986**	**0.99**	**972**	**892**	**0.90**	**1.18**	**1054**	**1.07**
1994	**593**	**0.97**	**577**	**1682**	**2.84**	**1.07**	**1801**	**3.04**
1995	**806**	**0.94**	**755**	**3890**	**4.83**	**1.23**	**4765**	**5.92**
1996	**1115**	**0.93**	**1041**	**5597**	**5.02**	**1.03**	**5776**	**5.18**
1997	**960**	**0.95**	**911**	**5527**	**5.75**	**0.76**	**4218**	**4.39**
1998	**652**	**0.96**	**625**	**3929**	**6.02**	**0.49**	**1926**	**2.95**
1999	1933	0.98	1894					
2000	6058	0.91	5524					
2001	6096	0.91	5553					
2002	7231	0.87	6257					
2003	2512	0.85	2134					
2004	1688	0.82	1380					
2005	671	0.84	563					

Table 6. Lower Mainstem John Day River summer steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		
delimited	median	75% threshold	median	75% threshold	1987-1998	1980-1998	Nat. origin geomean
Point Est.	3.02	2.85	2.59	2.99	0.97	1.02	1800
Std. Err.	0.25	0.34	0.18	0.24	0.35	0.35	0.29
count	9	7	9	7	12	19	10

Table 7. Stock-recruitment curve fit parameter estimates for the Lower Mainstem John Day River summer steelhead population. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.24	0.35	n/a	n/a	0.37	0.87	66.3	1.18	0.28	n/a	n/a	0.34	0.82	59.6
Const. Rec	2325	426	n/a	n/a	n/a	n/a	50.1	2202	287	n/a	n/a	n/a	n/a	37.2
Bev-Holt	50	110	2392	476	0.16	0.86	53.2	50	91	2264	326	0.27	0.42	40.3
Hock-Stk	3.58	0.66	652	1	0.16	0.86	52.9	2.99	1.20	750	317	0.26	0.42	39.8
Ricker	3.08	0.86	0.00035	0.00008	0.29	0.77	55.4	2.52	0.59	0.00030	0.00007	0.42	0.40	48.6

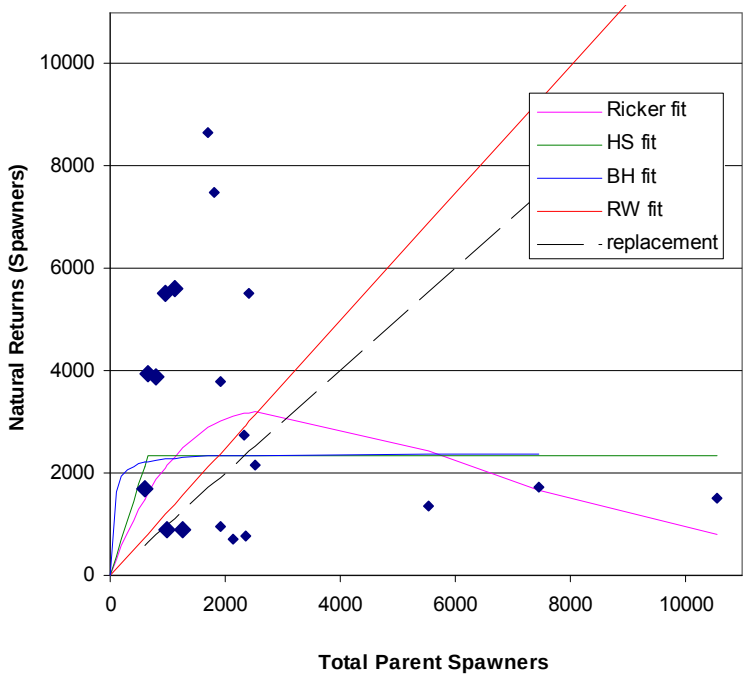


Figure 8. Lower Mainstem John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

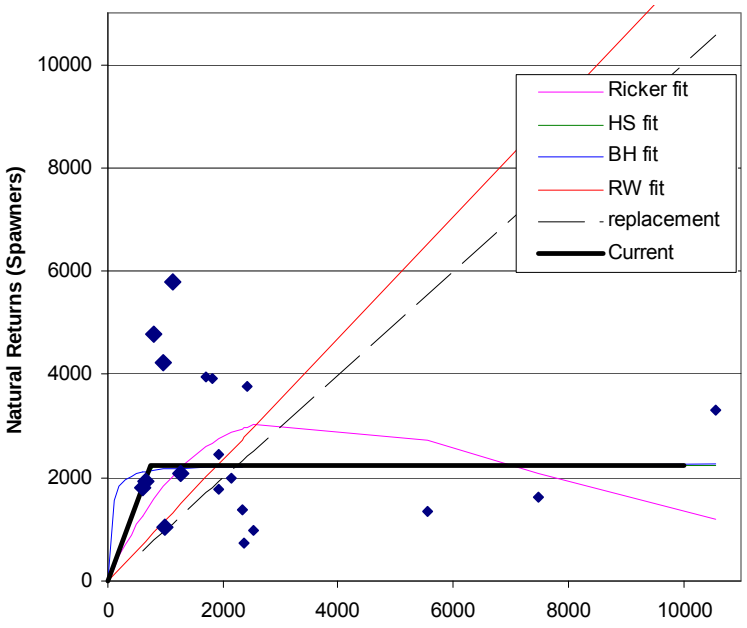


Figure 9. Lower Mainstem John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

North Fork John Day River Summer Steelhead Population

The North Fork John Day River summer steelhead population (Figure 1) is one of five populations in the John Day River MPG within the Mid-Columbia steelhead DPS. All five populations in this MPG are summer run.

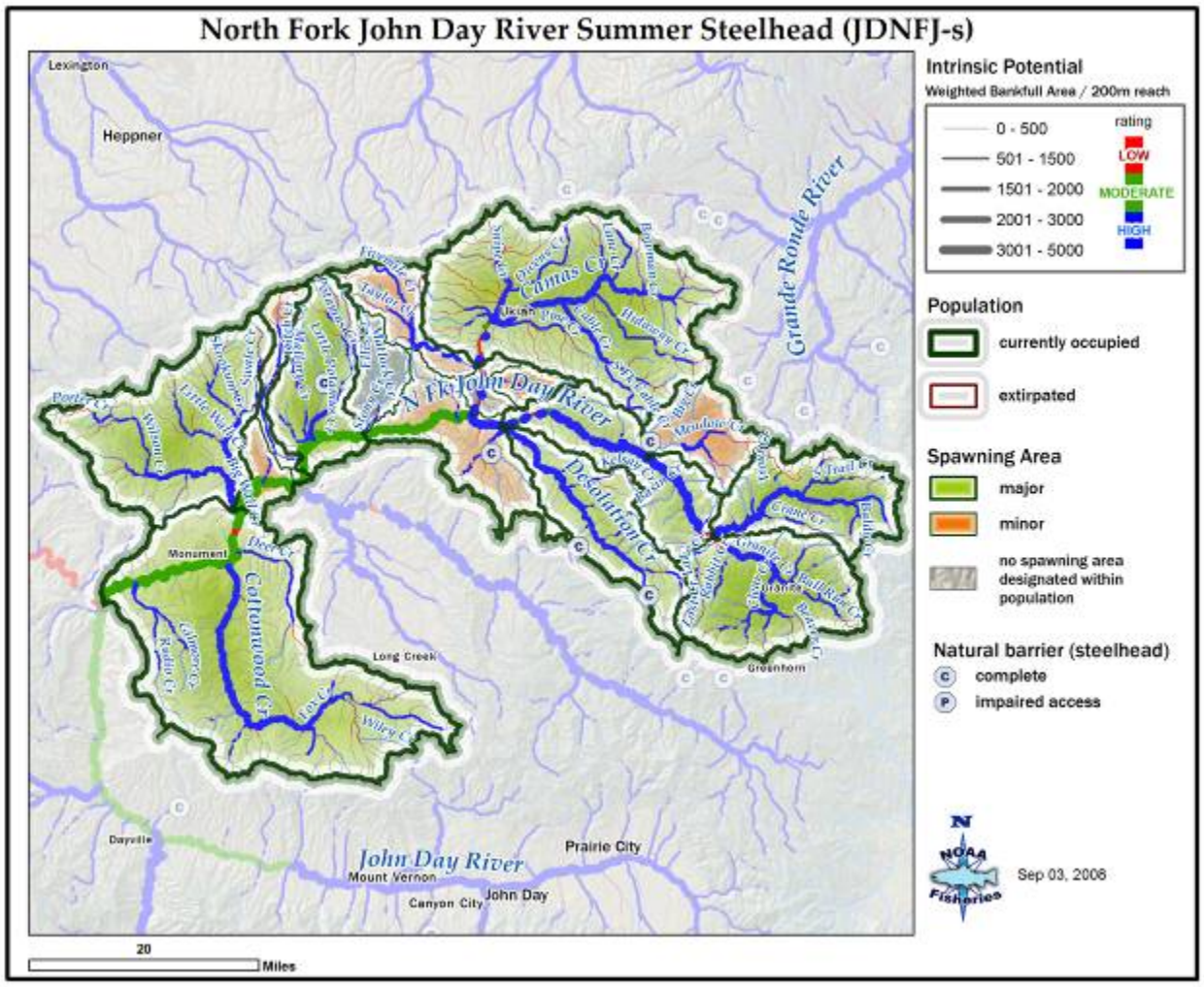


Figure 1. North Fork John Day River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the North Fork population as "large" in size and complexity (Table 1) based on historical habitat potential (ICTRT 2007). A steelhead population classified as large has a mean minimum abundance threshold criteria of 1,500 natural-origin spawners with sufficient intrinsic productivity (≥ 1.26 recruits per spawner at the abundance threshold level) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the North Fork John Day River population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.53 recruits per spawner at the minimum abundance threshold.

Table 1. North Fork John Day River summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	4,788
Stream lengths km (total) [a]	1,823
Stream lengths km (below natural barriers) [a]	1,678
Branched stream area weighted by intrinsic potential (km^2)	5.221
Branched stream area km^2 (weighted and temp. limited) [b]	4.917
Total stream area weighted by intrinsic potential (km^2)	6.867
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	6.474
Size / Complexity category	Large / "B" (dendritic)
Number of major spawning areas (MaSAs)	8
Number of minor spawning areas (MiSAs)	7

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

Current (1965-2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 369 in 1990 to 10,235 in 1965 (Figure 2). Abundance estimates are based on expanded redd counts. Index surveys of steelhead redds from the Oregon Department of Fish and Wildlife (ODFW), John Day District, were used for the historical dataset. We used index surveys that showed relatively consistent visitation through years. Survey data from Beaver, Fox, North Fork Trail, Middle Fork Trail, Wall and Wilson creeks were used in the analyses. The current spawning distribution was used for the miles of available habitat within the population's range. The index redd densities were then multiplied by a correction factor based on the ratio of index densities to EMAP (Environmental Monitoring and Assessment Program) densities for 2004-2005; this ratio was consistent for these years (0.36, 0.35). The estimated redd density for the entire spawning area (0.355 x index density) was multiplied by the total miles of currently utilized spawning habitat. Total annual redds were converted to fish by multiplying the total annual number of redds by the number of fish per redd. Fish/redd ratios were developed from survey data on Deer Creek in the Grande Ronde River basin. The ratio is an average from four years of data of complete and repeated surveys (censuses) of redds above a weir where we have a complete count; the calculated average fish per redd estimate was 2.1.

The hatchery-origin/natural-origin composition of spawners were computed separately for the Lower Mainstem John Day River population and combined for all other populations in the MPG. Data used to represent the North Fork population included observations of positively identified fin-clipped spawners (1992-present) from spawning survey observations in the four populations above the Lower Mainstem, and observations from rotary screw trap and seine collections of adults (2000-present). There is evidence from the Deschutes River that hatchery straying was substantially lower before 1992, and since the source of strays in the John Day River basin is the same as the Deschutes River, we are assuming a similar trend. No other data are available for earlier years so the hatchery fraction was set at zero. Age composition was derived from scale readings of creel sampled unmarked fish collected during the 1980s above Tumwater Falls.

Recent year natural spawners include returns originating from naturally spawning parents, and a small fraction of strays from the Snake and Columbia River hatchery programs. Since documentation of hatchery strays began in 1992, spawners originating from naturally spawning parents have comprised an average of 93% of the spawners, ranging from 87-99%.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 1,740 (1,898 total spawners; Table 2). During the period 1979-1998, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the North Fork John Day River ranged from 0.10 in 1985 to 3.07 in 1991. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 20-year (1979-1998) geometric mean productivity was 2.41 R/S, adjusted for SAR and delimited at 75% (1,125 spawners) of the abundance threshold (Table 2).

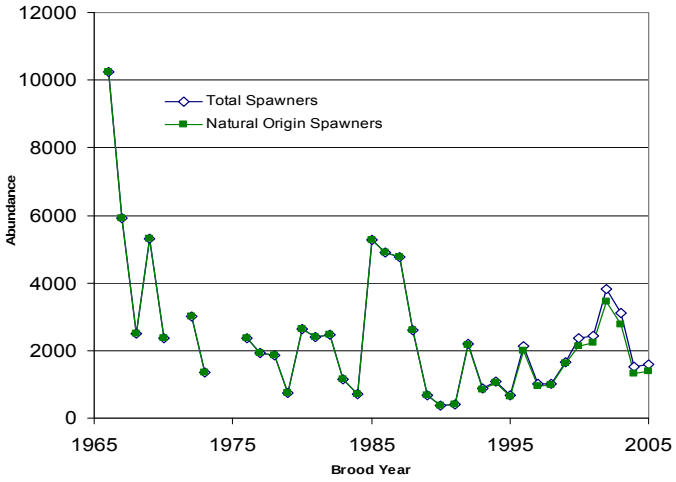


Figure 2. North Fork John Day River summer steelhead population spawner abundance estimates (1966-2005).

Table 2. North Fork John Day River summer steelhead population abundance and productivity estimates.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	1740	(369-10,235)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.93	(0.87-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (20-year R/S, SAR adjusted & delimited) [a]	2.41	(1.31-4.42)	0.22
Productivity (20-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	0.99	(0.95-1.16)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	1.00	(0.79-1.25)	0.48
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.00	(0.80-1.26)	0.51

a. Delimited productivity excludes any recruit/spawner pair where spawner number >75% of population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The North Fork John Day River population is at **Very Low Risk** based on current abundance and productivity. The point estimate for abundance and productivity is above the 1% risk curve (Figure 3) and the lower end of the 98% confidence interval (CI) for productivity is above the 25% risk curve.

The abundance of natural-origin spawners in the North Fork population has fluctuated substantially over the recent 20-year period. The average trend in natural-origin spawner abundance has been 0.99; the

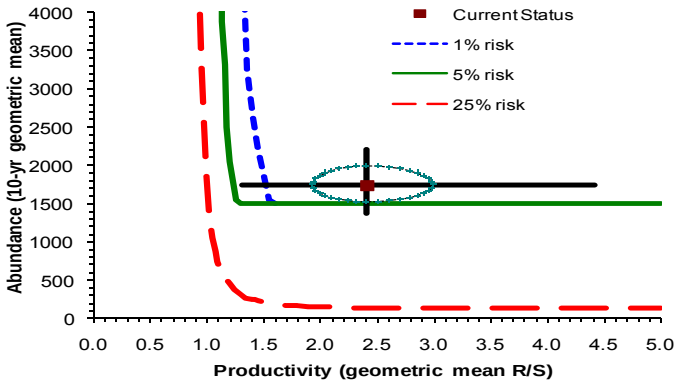


Figure 3. North Fork John Day River summer steelhead population current abundance and productivity (A/P) compared to DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A, 98% CI for P (if point estimate >1% risk curve, the uncertainty test is <1% probability the combined A/P is at high risk).

population growth rate metric (calculated with relative hatchery effectiveness set to 1.0) was 1.00 for the same period (Table 2). The pattern in returns from 1991 through 2005 is similar to the pattern for several other Mid-Columbia DPS steelhead populations, including the Deschutes River Eastside—an increasing trend beginning in 1996 followed by an abrupt decrease to levels observed in the early 1990s. The estimated proportion of spawners of hatchery-origin has averaged approximately 7% for the period. The relative effectiveness of hatchery-origin spawners in contributing to natural production in this population is not known. Setting the value to 0.0 did not change the point estimate of the average population growth rate for the period, although the probability of exceeding 1.0 increased slightly from 0.48 to 0.51.

Spatial Structure and Diversity

The ICTRT has identified eight major spawning areas (MaSAs) and seven minor spawning areas (MiSAs) within the North Fork John Day River steelhead population (Figure 4). Spawning is distributed broadly throughout the population boundaries including many tributaries and mainstem areas of Cottonwood, Camas, Desolation, and Granite creeks and the upper North Fork John Day River. Spawners in the North Fork John Day River are primarily natural-origin fish; however, outside-DPS hatchery fish, primarily from Snake River stocks, are present in the North Fork population.

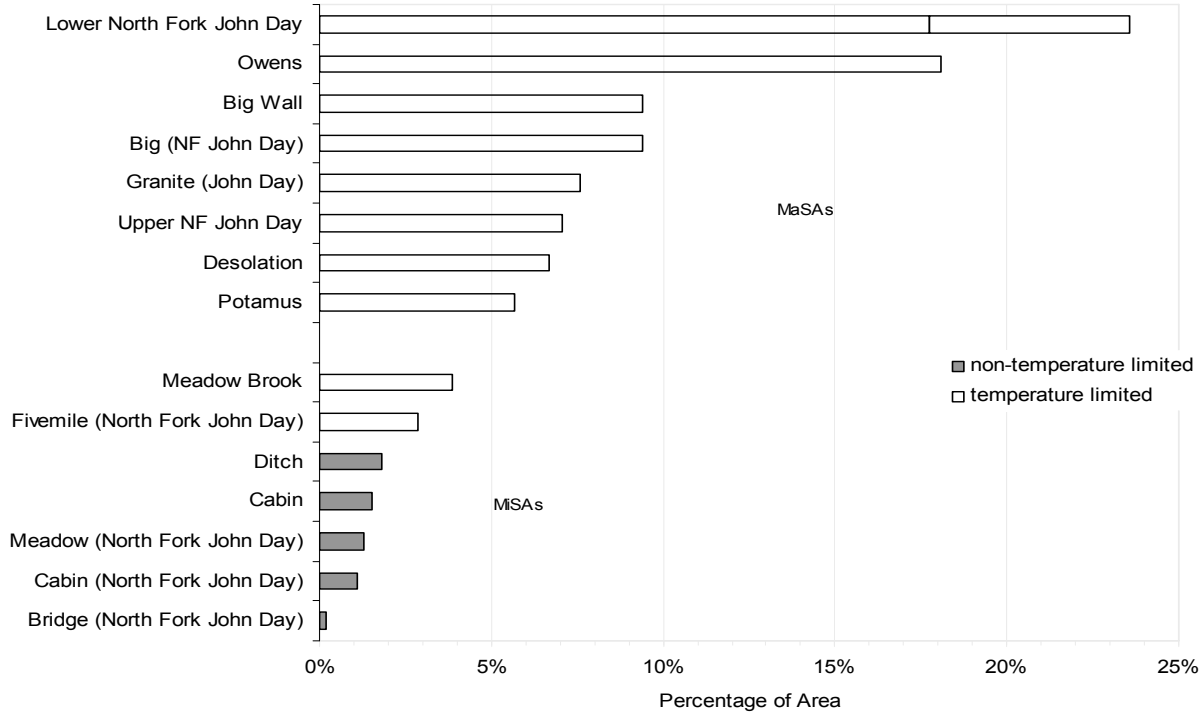


Figure 4. North Fork John Day River summer steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs). White bars represent areas that could potentially have had historical temperature limitations.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The North Fork John Day River population has eight MaSAs and seven MiSAs which are distributed in a complex dendritic pattern. Based on the ODFW spawner distribution database all eight MaSAs and seven MiSAs are currently occupied and a total of 1,194 km are presently used for spawning (Figure 5). The North Fork population rates at **very low risk** for this metric because it has more than four MaSAs occupied in a dendritic configuration.

A.l.b. Spatial extent or range of population

The current spawner distribution mirrors the historical distribution represented by the intrinsic potential analyses. All MaSAs and MiSAs are currently occupied (Figure 5). The current spatial extent and range criteria rating for the North Fork population is **very low risk**. Index area spawning surveys are conducted in six spawning tributaries in the North Fork population.

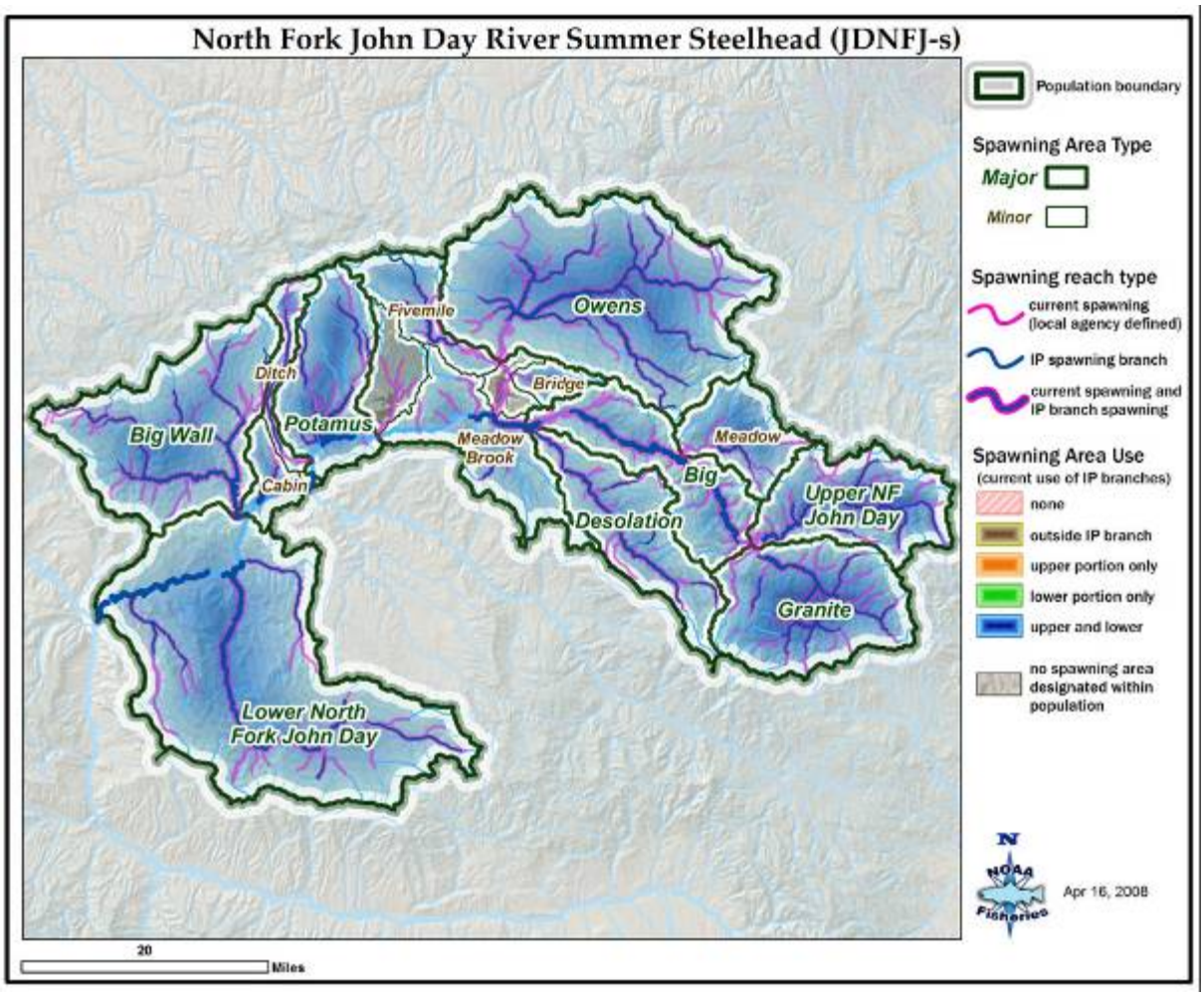


Figure 5. North Fork John Day River summer steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There have been no significant increases in gaps between spawning areas. Connectivity between historic spawning areas has remained relatively unchanged. The North Fork population rates at **very low risk** for gaps.

B.1.a. Major life history strategies

There are limited data for evaluating specific life history patterns of North Fork John Day River steelhead, and therefore we use habitat information to infer changes in life history strategies. A

significant proportion of the North Fork population resides in wilderness area with habitat conditions that are relatively unaltered. Habitat conditions throughout the population do theoretically provide the opportunity for expression of all historic life history strategies. The North Fork John Day River population is an A-run population with ocean migration occurring predominantly at age 2 and age 3, and adults returning after one or two years in the ocean. These life history patterns are consistent with what we observe for most A-run populations. We have no evidence of loss of major life history strategies, thus the rating is **very low risk** for this metric.

B.1.b. Phenotypic variation

Data were not available to evaluate if any phenotypic traits have been lost. We used habitat information to infer potential changes in phenotypic traits. Relatively unaltered habitat conditions across a significant proportion of the population results in the absence of significant phenotypic selective pressures, thus the population is at **very low risk** for loss of phenotypic traits.

B.1.c. Genetic variation

There are limited genetic data for John Day River steelhead populations, with only one sample from the North Fork population. The populations within the John Day MPG are not well differentiated from one another. There is no biological basis to explain why the samples did not show normal differentiation. There are no past events, such as severe population bottlenecks or hatchery outplanting that would explain these results. There are out-of-DPS strays in the John Day River basin but the degree of introgression is unknown, and the past genetic samples, which were collected in the 1980s, were taken at a time when stray proportions were likely lower than in recent years. We have assigned a rating of **low risk** for this metric. This rating is driven by the balance between apparent similarity within and between populations and the relative degree of differentiation. Samples were collected in 2005 that will better inform the risk assessment for genetic variation in the future.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners:* Available data were inadequate to estimate the out-of-DPS hatchery fraction specifically for the North Fork population. The estimates derived were based on data from a composite of the four populations (South Fork, Middle Fork, Upper John Day, and North Fork) in the John Day River MPG that are above the Lower Mainstem population. These estimates were calculated from observations from spawning surveys and kelt collections seined from the mainstem. Since 1992, the estimated hatchery fraction ranged from 0.01-0.13. The mean hatchery fraction was 0.067. Based on coded wire tags (CWTs) recovered primarily from recreational fisheries, the majority of stray hatchery fish originate from Snake River hatcheries. Given that the hatchery fraction of out-of-DPS strays is estimated to be greater than 0.05 for two or more generations, the rating is **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS:* There have been four fish with CWTs recovered in the John Day River from out-of-MPG within-DPS origin. Three originated from

the Umatilla Hatchery program and one from the Deschutes. It appears very few within-DPS hatchery fish stray into the John Day River, thus the rating is **low risk** for this metric.

(3) *Out-of-population spawners from within the MPG:* There are no steelhead hatchery programs operated within the John Day River basin, therefore this metric is rated **very low risk**.

(4) *Within-population hatchery spawners:* There are no steelhead hatchery programs operated within the John Day River basin, therefore this metric is rated as **very low risk**.

The overall rating for the spawner composition metric is **high risk** due to the high proportion of out-of-DPS strays that spawn naturally in this population**.**

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution of the North Fork John Day River summer steelhead population encompassed six ecoregions, with the John Day Clarno Highlands and Mesic Forest zone comprising slightly over 60% of the distribution (Table 3). There are four ecoregions that comprise greater than 10% of the historic distribution. There has been little change in ecoregion distribution between intrinsic and current distribution with all six ecoregions currently occupied at nearly identical proportions as the intrinsic distribution (Figure 6). There have been no substantial reductions in any of the ecoregions. The rating for this metric is **very low risk**.

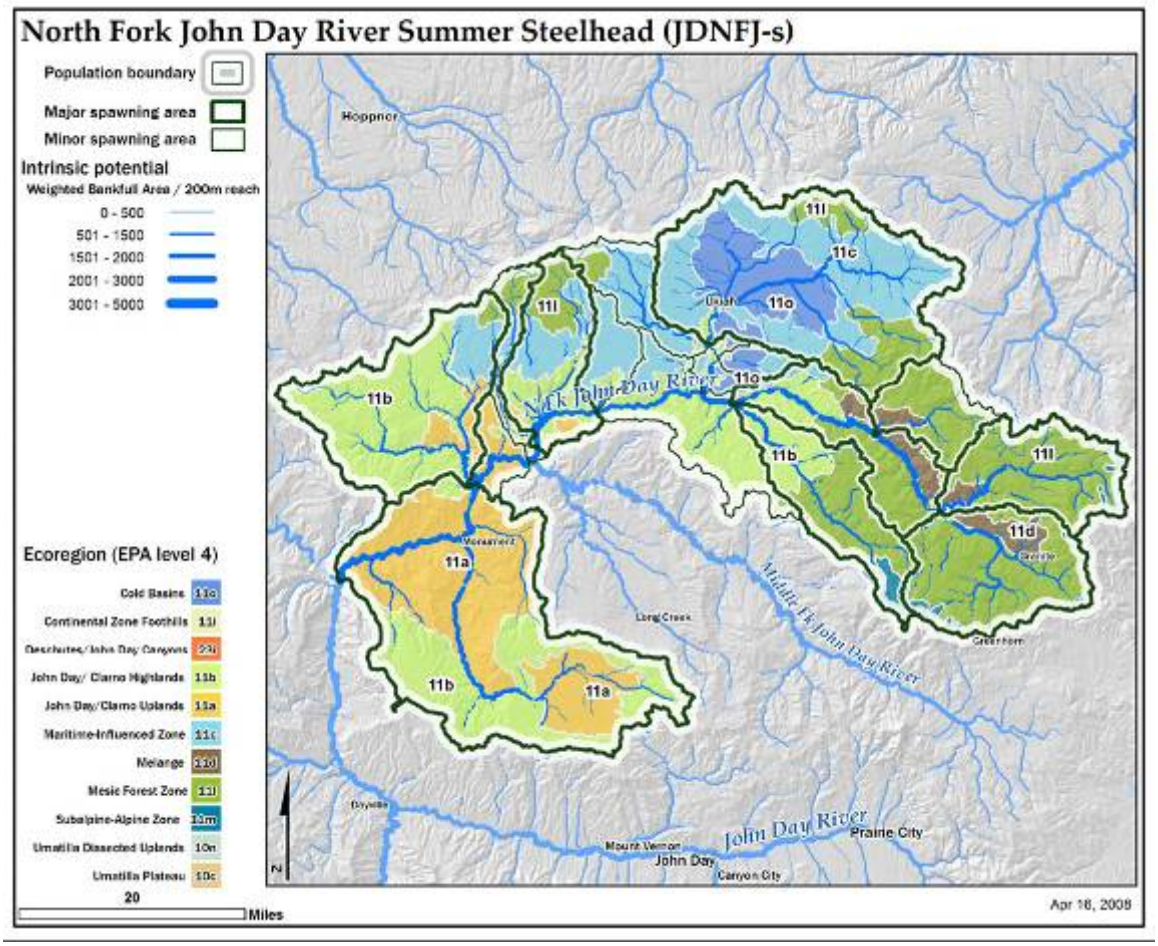


Figure 6. North Fork John Day River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. North Fork John Day River summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Cold Basins	8.3	10.4
John Day Clarno Highlands	27.0	26.4
John Day Clarno Uplands	26.6	16.9
Maritime-Influenced Zone	10.4	11.9
Melange	2.4	3.3
Mesic Forest Zone	25.3	31.2

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population crosses three dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Adult migration timing:* These dams establish a thermal barrier in the reservoirs that delays and potentially induces some mortality of migrating adults. This barrier is diminished later in the migration season. Because the timing of the barrier varies from year to year and does not develop in some years, and the degree of differential survival is likely low and not well-understood, we rate the selection intensity as low. Heritability of this trait is high, thus the hydropower rating for this trait is **moderate risk**.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is very limited tribal harvest of natural-origin fish within the John Day River subbasin; impacts from the recreational fishery are incidental to hatchery-origin fish harvest and are not selective. No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: There are no steelhead hatchery programs operated within the population; therefore, the hatchery rating is **very low risk** for all traits.

Habitat: Little change in flow profile and temperature has occurred within the population boundaries. However, some change has occurred in the mainstem John Day River which would affect the North Fork population.

> *Adult migration timing:* Low flows in the late summer and early fall in the John Day River likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable, but a negligible proportion of the population is likely subject to these effects. Thus, the impact of habitat changes on this trait is **low.**
>
> *Juvenile migration timing:* Late spring and early summer temperatures are elevated relative to historical conditions. There has likely been some effect on juvenile migration timing as temperatures can reach stressful levels in the John Day River mainstem in late spring and early summer in some years. Selection intensity is considered negligible and the heritability of this trait is moderate to low. The rating for this trait is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

Juvenile migration timing: Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

There is only one trait that has a moderate rating for one selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The combined integrated spatial structure/diversity rating is **Low Risk** for the North Fork John Day River population (Table 4). The rating for Goal A (allowing natural rates and level of spatially mediated processes) was **very low risk**. The current spawner distribution mimics the intrinsic distribution. The population is distributed broadly across the landscape in numerous MaSAs and MiSAs. Good continuity exists between spawning areas and current gaps between spawning areas are similar to historic gaps.

The rating for Goal B (maintaining natural levels of variation) was **low risk**. However, there remains considerable uncertainty about the ratings for genetic variation and out-of-DPS hatchery strays in the natural spawners. Additional genetic analyses and interpretation is needed to determine the degree of genetic variation and differentiation, as well as to examine evidence for degree of stray hatchery fish introgression. We rated the metric for out-of-DPS hatchery strays as very high. The data used for this rating are a composite from four John Day River populations. Additional population-specific spawner composition data are needed to improve the certainty of the out-of-DPS stray hatchery risk rating. If there is significant hatchery introgression that is affecting the genetic variation through time then the risk rating for "genetic variation" will increase and the overall risk rating for Goal B and spatial structure/diversity will also increase.

Table 4. North Fork John Day River summer steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Very Low Risk
(Mean = 2)</td><td rowspan="3">Very Low Risk
(Mean = 2)</td><td rowspan="14">Low Risk</td></tr>
<tr><td>A.1.b</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>A.1.c</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Low Risk (1)</td><td rowspan="10">Low Risk
(Mean = 0.75)</td></tr>
<tr><td>B.1.b</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>L (1)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>VL (2)</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The North Fork John Day River summer steelhead population currently meets ICTRT viability criteria and is rated **HIGHLY VIABLE** (Figure 7). Overall abundance and productivity is rated at **Very Low Risk.** The 10-year geometric mean abundance of natural-origin spawners is 1,740, which exceeds the minimum abundance threshold of 1,500. The 20-year geometric mean productivity (2.41 R/S; Table 6) is well above the 1.26 R/S required at the minimum abundance threshold. Overall spatial structure and diversity is rated at **Low Risk.** The ratings for genetic variation and out-of-DPS hatchery-origin spawner composition were the most influential on the overall spatial structure/diversity assessment. There is considerable uncertainty regarding the genetic effect of out-of-DPS strays, as well as the actual proportion of natural spawners that are hatchery strays. There are limited population-specific data to estimate the spawner composition in the North Fork population. Enhanced monitoring efforts should be undertaken to develop better estimates of the composition of North Fork John Day River spawners.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV** **North Fork John Day River**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M**	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. North Fork John Day River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – North Fork John Day River

Data type: Redd count expansion - Index area redd counts expanded to total population estimate by applying ratio of average redd densities (samples across all areas to samples from index reaches) from EMAP surveys. Assumed 2.1 fish per redd.

Smolt-to-Adult Return rate (SAR): Mid-Columbia composite series (see *Methods*).

Table 5. North Fork John Day River summer steelhead population abundance and productivity data used for curve fits and R/S analysis. Bold values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1979	**757**	**1.00**	**757**	**1358**	**1.79**	**1.94**	**2633**	**3.48**
1980	2633	1.00	2633	3167	1.20	0.50	1599	0.61
1981	2390	1.00	2390	5041	2.11	0.68	3442	1.44
1982	2473	1.00	2473	4598	1.86	0.46	2101	0.85
1983	1153	1.00	1153	3383	2.94	0.52	1772	1.54
1984	**704**	**1.00**	**704**	**1521**	**2.16**	**0.65**	**984**	**1.40**
1985	5264	1.00	5264	522	0.10	0.46	240	0.05
1986	4895	1.00	4895	563	0.11	0.94	531	0.11
1987	4754	1.00	4754	1240	0.26	2.18	2699	0.57
1988	2603	1.00	2603	1460	0.56	0.99	1446	0.56
1989	**687**	**1.00**	**687**	**925**	**1.35**	**0.96**	**889**	**1.29**
1990	**369**	**1.00**	**369**	**955**	**2.59**	**2.83**	**2703**	**7.33**
1991	**415**	**1.00**	**415**	**1274**	**3.07**	**2.33**	**2973**	**7.16**
1992	2185	0.99	2154	1425	0.65	1.88	2679	1.23
1993	**867**	**0.99**	**855**	**1036**	**1.19**	**1.18**	**1224**	**1.41**
1994	**1078**	**0.97**	**1050**	**1385**	**1.29**	**1.07**	**1483**	**1.38**
1995	**683**	**0.94**	**640**	**1922**	**2.82**	**1.23**	**2355**	**3.45**
1996	2122	0.93	1981	2309	1.09	1.03	2383	1.12
1997	**1013**	**0.95**	**961**	**2823**	**2.79**	**0.76**	**2155**	**2.13**
1998	**1021**	**0.96**	**978**	**2930**	**2.87**	**0.49**	**1437**	**1.41**
1999	1660	0.98	1626					
2000	2350	0.91	2143					
2001	2448	0.91	2230					
2002	3828	0.90	3444					
2003	3093	0.89	2758					
2004	1527	0.87	1328					
2005	1602	0.87	1393					

Table 6. North Fork John Day River summer steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		
delimited	median	75% threshold	median	75% threshold	1987-1998	1979-1998	Nat. origin geomean
Point Est.	2.07	2.07	2.41	2.41	1.01	1.09	1740
Std. Err.	0.12	0.12	0.22	0.22	0.02	0.15	0.13
count	10	10	10	10	12	20	10

Table 7. North Fork John Day River summer steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.17	0.27	n/a	n/a	0.71	0.55	62.0	1.15	0.30	n/a	n/a	1.09	0.46	67.8
Const. Rec	1653	228	n/a	n/a	n/a	n/a	42.1	1622	230	n/a	n/a	n/a	n/a	43.2
Bev-Holt	12.92	19.48	1871	441	0.18	0.72	44.4	50.00	68.78	1665	252	0.35	0.39	46.4
Hock-Stk	2.03	0.46	951	266	0.21	0.64	43.5	4.68	0.10	347	1	0.34	0.39	46.0
Ricker	3.76	0.60	0.00061	0.00007	0.13	0.59	31.5	4.32	0.86	0.00070	0.00008	0.29	0.11	40.1

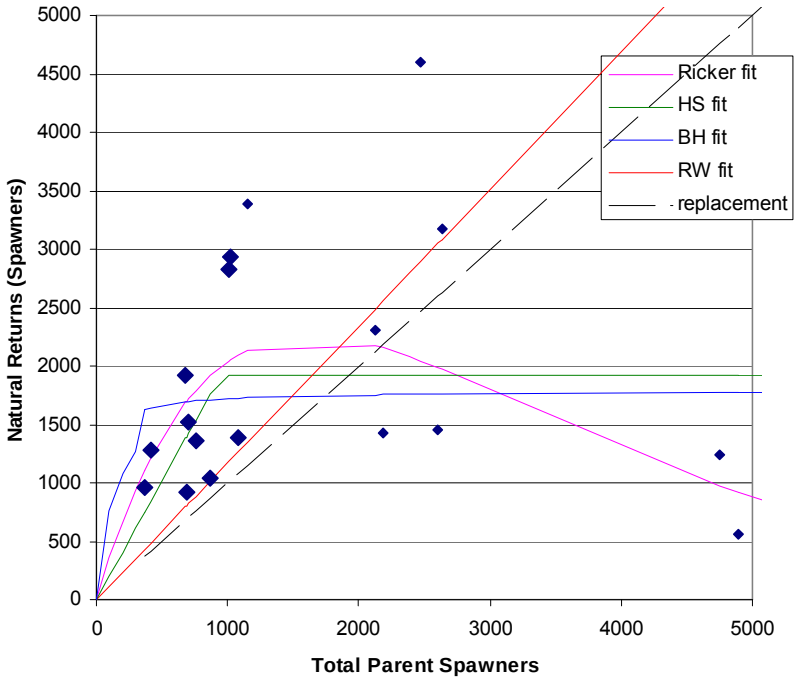


Figure 8. North Fork John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

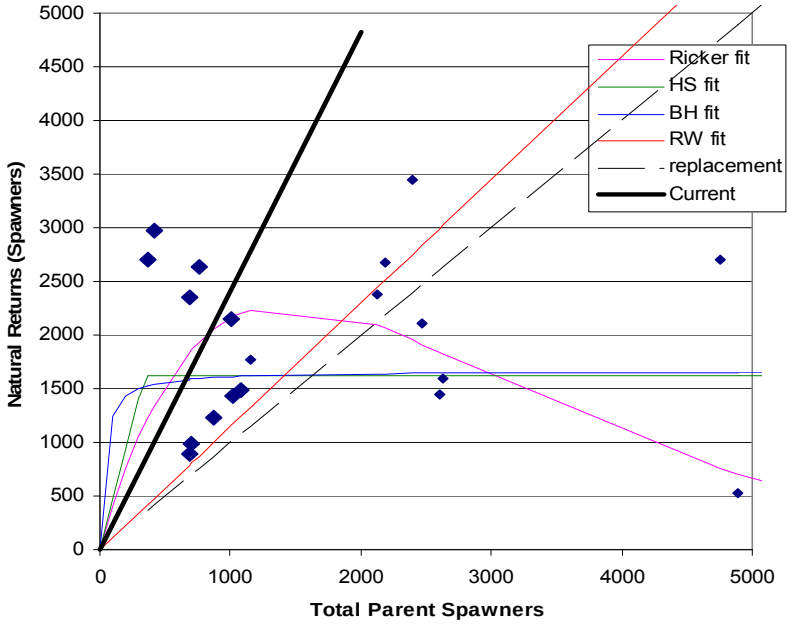


Figure 9. North Fork John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Middle Fork John Day River Summer Steelhead Population

The Middle Fork John Day River summer steelhead population (Figure 1) is one of five populations in the John Day River MPG within the Mid-Columbia steelhead DPS. All five populations in this MPG are summer run.

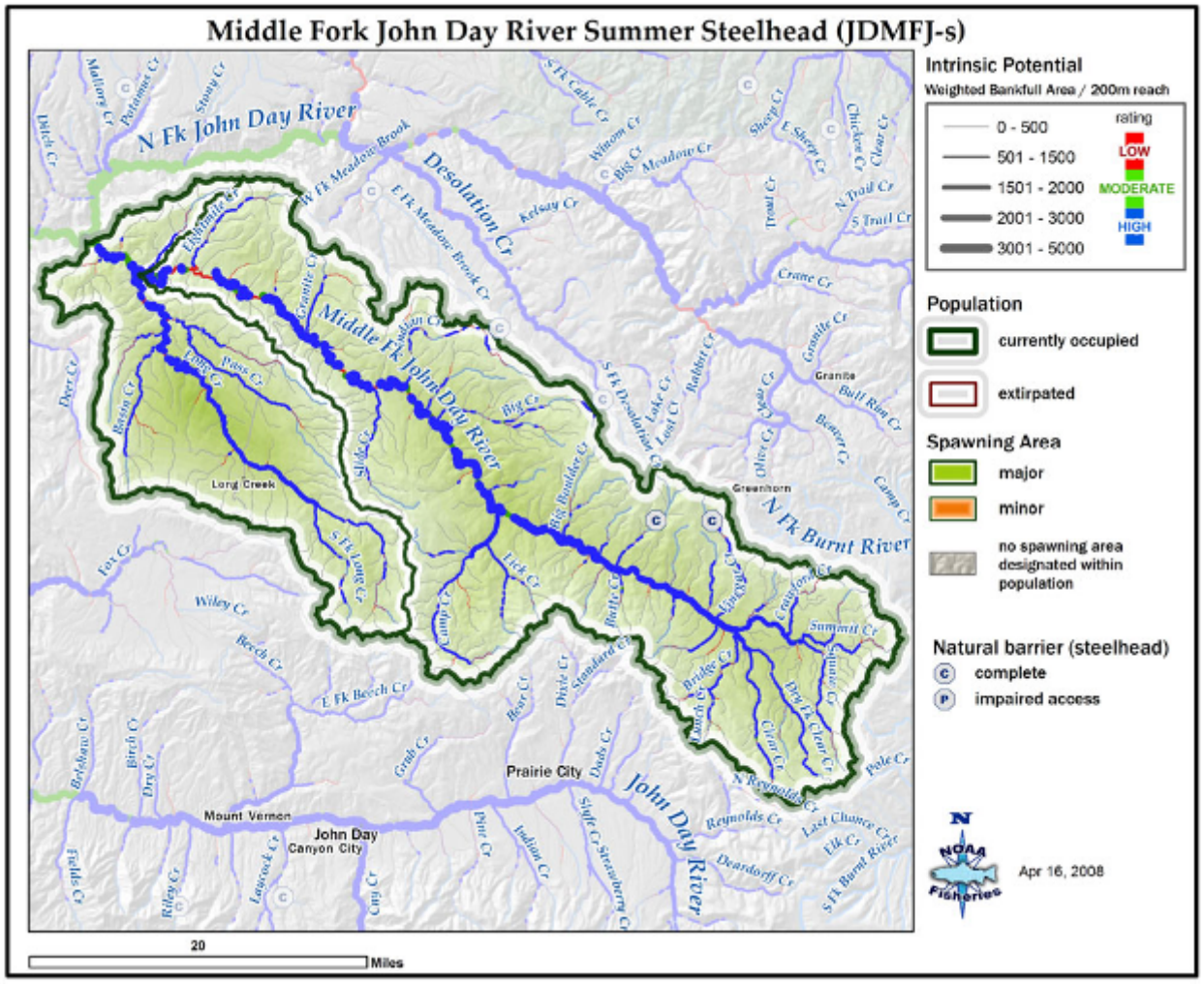


Figure 1. Middle Fork John Day River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Middle Fork population as "intermediate" in size and complexity (Table 1) based on historical habitat potential (ICTRT 2007). A steelhead population classified as intermediate has a mean minimum abundance threshold of 1,000 natural-origin spawners with a sufficient intrinsic productivity (≥ 1.35 recruits per spawner at the minimum abundance threshold) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the Middle Fork population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.64 recruits per spawner at the minimum abundance threshold.

Table 1. Middle Fork John Day River summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	2,052
Stream lengths km (total) [a]	704
Stream lengths km (below natural barriers) [a]	690
Branched stream area weighted by intrinsic potential (km^2)	2.592
Branched stream area km^2 (weighted and temp. limited) [b]	2.592
Total stream area weighted by intrinsic potential (km^2)	2.963
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	2.963
Size / Complexity category	Intermediate / "B" (dendritic structure)
Number of major spawning areas (MaSAs)	2
Number of minor spawning areas (MiSAs)	0

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

Current (1966-2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 337 in 2005 to 3,538 in 1979 (Figure 2). Abundance estimates are based on expanded redd counts. Index surveys of steelhead redds from the Oregon Department of Fish and Wildlife (ODFW), John Day District, were used for the historical dataset. We used index surveys that showed relatively consistent visitation through years (Beaver, Camp, Deep, and Lick creeks). The current spawning distribution was used for the miles of available habitat within each population's range. The index redd densities were then multiplied by a correction factor based on the ratio of index densities to EMAP (Environmental Monitoring and Assessment Program) densities for 2004-2005; the ratio was consistent for these years (0.36, 0.35). The estimated redd density for the entire spawning area (0.355 x index density) was multiplied by the total miles of currently utilized spawning habitat. Total annual redds were converted to fish by multiplying the total annual number of redds by the number of fish per redd. Fish/redd ratios were developed from four years of data of complete and repeated surveys (censuses) on Deer Creek in the Grande Ronde River basin of redds above a weir where we have a complete count. The average fish per redd estimate from Deer Creek was 2.1.

The hatchery-origin/natural-origin composition of spawners were computed separately for the Lower Mainstem John Day River population, and combined for all other populations in the MPG. Data used to represent the Middle Fork population included observations of positively identified adipose fin-clipped spawners (1992-present) from spawning survey observations in the four populations above the Lower Mainstem population, and observations from rotary screw trap and seine collections of adults (2000-present). There is evidence from the Deschutes River that hatchery straying was substantially lower before 1992, and because the source of strays in the John Day River subbasin is the same as the Deschutes River, we are assuming a similar trend. No other data are available for earlier years so the hatchery fraction was set at zero. Age composition was derived from scale readings of creel sampled unmarked fish collected during the 1980s from locations above Tumwater Falls.

Recent year natural spawners include returns originating from naturally spawning parents, and a small fraction of strays from the Snake and Columbia River hatchery programs. Since documentation of hatchery strays began in 1992, spawners originating from naturally spawning parents have comprised an average of 93%, ranging from 87%-99%.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 756 (Table 2). During the period 1969-1998, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Middle Fork John Day River ranged from 0.17 in 1992 to 3.84 in 1997. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 20-year (1979-1998) geometric mean productivity was 2.45 R/S, adjusted for SAR and delimited at 75% (563 spawners) of the abundance threshold (Table 2).

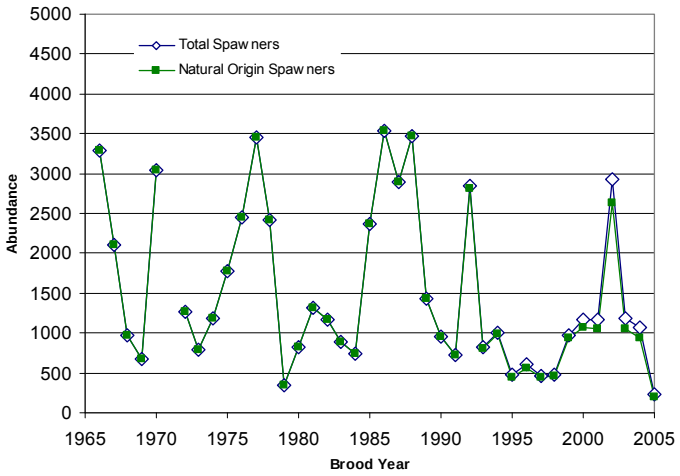


Figure 2. Middle Fork John Day River summer steelhead spawner abundance estimates (1966-2005).

Table 2. Middle Fork John Day River summer steelhead population abundance and productivity.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	756	(195-3538)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.93	(0.87-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (20-year R/S, SAR adjusted & delimited) [a]	2.45	(1.81-3.32)	0.16
Productivity (20-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	0.97	(0.93-1.06)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	1.00	(0.79-1.26)	0.50
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.01	(0.80-1.27)	0.53

a. Delimited productivity excludes any recruit/spawner pair where the spawner number >75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Middle Fork John Day River population is at **Moderate Risk** based on current abundance and productivity. The point estimate is between the 5% and 25% risk curves (Figure 3).

The abundance of natural-origin spawners in the Middle Fork population has fluctuated substantially over the recent 20-year period. The average trend in natural-origin spawner abundance has been 0.97; the population growth rate metric (calculated with relative hatchery effectiveness set to 1.0) was 1.00 for the same period (Table 2). The pattern in returns from 1991 through 2005 is similar

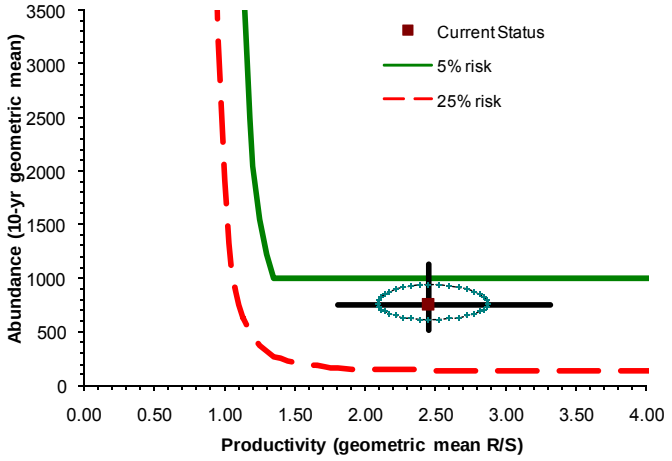


Figure 3. Middle Fork John Day River summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

to the pattern for several other Mid-Columbia DPS steelhead populations, including the Deschutes River Eastside—an increasing trend beginning in 1996 followed by an abrupt decrease to levels observed in the early 1990s. The estimated proportion of spawners of hatchery-origin has averaged approximately 7% for the period. The relative effectiveness of hatchery-origin spawners in contributing to natural production in this population is not known. Setting the value to 0.0, the opposite extreme from 1.0, results in an estimated annual growth rate of 1.01 (0.53 probability of exceeding 1.0).

Spatial Structure and Diversity

The ICTRT has identified two major spawning areas (MaSAs) and no minor spawning areas (MiSAs) within the Middle Fork John Day River summer steelhead population (Figure 4). Spawning is distributed broadly throughout the population boundaries including mainstem areas in the lower and upper Middle Fork John Day River and Long Creek. There are numerous tributary spawning streams distributed from the lower end of the population boundary to the uppermost reaches. Spawners within the Middle Fork John Day River are primarily natural-origin fish; however, outside-DPS hatchery fish, primarily from Snake River stocks, are present in the Middle Fork population.

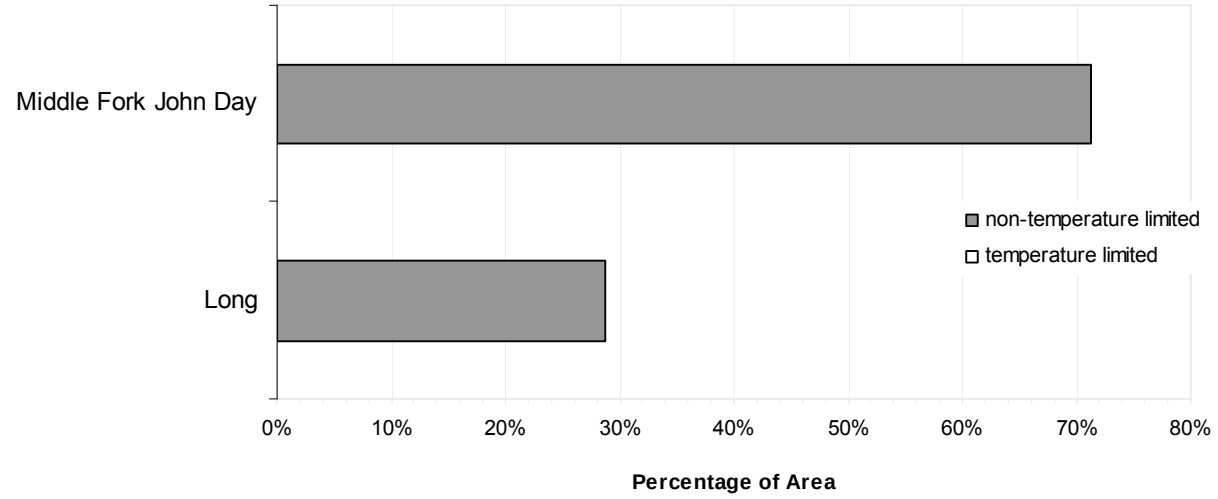


Figure 4. Middle Fork John Day River summer steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs).

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Middle Fork population has two MaSAs (no MiSAs) which are distributed in a dendritic pattern. Based on the ODFW spawner distribution database all of the major and minor spawning areas are occupied and a total of 546 km are currently used for spawning (Figure 5). The Middle Fork population rates at **low risk** because it has two MaSAs occupied in a non-linear configuration.

A.l.b. Spatial extent or range of population

The current spawner distribution mirrors the historical distribution as represented by the intrinsic potential analyses. All MaSAs are currently occupied (Figure 5). The current spatial extent and range criteria are rated as **very low risk** for the Middle Fork population. There are four index spawning survey reaches in the Middle Fork population. Recent spawning ground surveys results will be analyzed for future viability assessments.

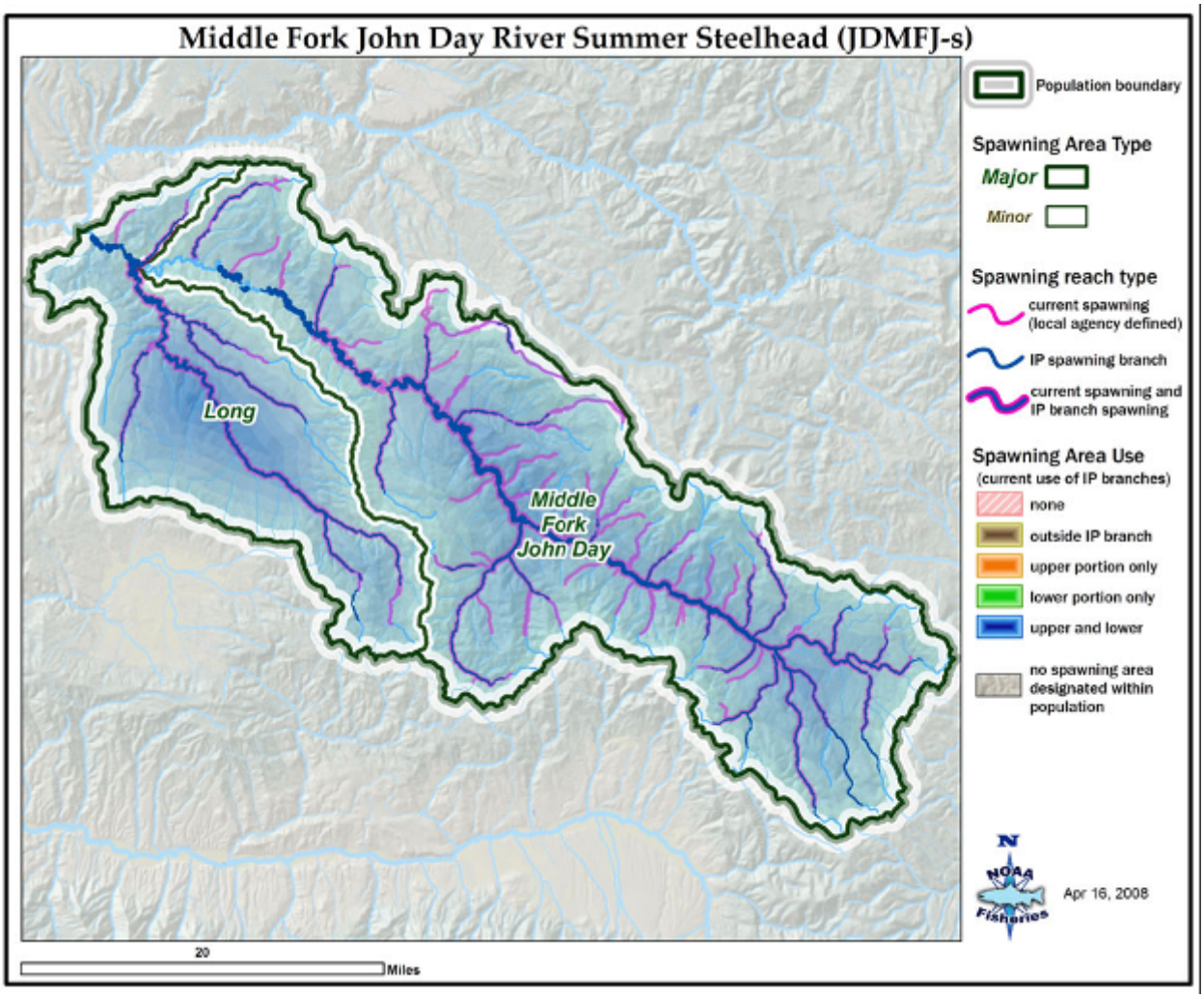


Figure 5. Middle Fork John Day River summer steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There has been little or no increase in gaps or loss in continuity between spawning areas within the Middle Fork population. Thus, the Middle Fork population rates as **low risk** for gaps and continuity.

B.1.a. Major life history strategies

There are no direct observations to assess loss in major life history strategies for the Middle Fork John Day River steelhead population; therefore we infer loss of life history diversity based on habitat changes. Although habitat conditions, particularly temperature, have been altered through time, there remains the theoretical opportunity to express diverse life history strategies similar to intrinsic potential. Juvenile steelhead exhibit diverse patterns of movement throughout their life cycle and rear in a variety of habitat types. Middle Fork John Day River steelhead are A-Run steelhead and appear to exhibit typical A-Run age at out-migration and ocean residence duration. The rating for loss of life history strategies is **low risk** for this metric.

B.1.b. Phenotypic variation

Current habitat conditions are not such that selective pressures would have significantly changed or eliminated any phenotypic traits. Mainstem Columbia River migrating corridor temperature changes and temperature changes in the John Day River have likely altered juvenile migration timing, thus reducing trait variability. We hypothesize that conditions have not altered the mean or variability of traits to the point that the risk level rises to moderate. Current habitat conditions and absence of other significant phenotypic selective pressure indicate that the Middle Fork population is at **low risk** for this metric.

B.1.c. Genetic variation

There are limited genetics data for John Day River steelhead populations and only one sample from the Middle Fork population. The samples from populations within the John Day River MPG are not well differentiated from one another. However, these samples were taken from a relatively small geographic area over a short time frame. There is no biological basis for the low level of differentiation. Samples were collected in the mid-1980s before any significant potential effects of hatchery strays. There have been no bottlenecks or other demographic factors that would have resulted in genetic variation impairment. There are out-of-DPS strays in the Middle Fork population; however the degree of introgression is unknown. We have assigned a rating of **low risk** for this metric. This rating is driven by balance between apparent similarity within and between populations and the relative degree of differentiation within and between the John Day River populations. Samples from multiple locations were collected in 2005 and will be analyzed to better inform the risk rating for this metric in the future.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners*: Inadequate data exist to estimate the out-of-DPS hatchery fraction specifically for the Middle Fork population. Estimates we used in this assessment were based on data from a composite of the four populations (South Fork, Middle Fork, Upper John Day, and North Fork) in the John Day River MPG that are above the Lower Mainstem population. These estimates are based on observations from spawning surveys and kelt collections seined from the mainstem. Since 1992, the estimated hatchery fraction ranged from 0.01-0.13. The mean hatchery fraction was 0.067. Based on recovery of hatchery fish with coded wire tags (CWTs), primarily from angler caught fish, the majority of stray hatchery fish originate from Snake River

hatcheries. Given that the hatchery fraction of out-of-DPS strays is estimated to be greater than 0.05 for two or more generations, the rating is **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS*: There have been four steelhead with CWTs recovered in the John Day River MPG from out-of-MPG within-DPS origin. Three originated from the Umatilla Hatchery program and one from the Deschutes. It appears very few within-DPS hatchery fish stray into the John Day River, thus the rating is **low risk** for this metric.

(3) *Out-of-population spawners from within the MPG:* There are no steelhead hatchery programs operated within the John Day River basin, therefore this metric is rated as **very low risk**.

(4) *Within-population hatchery spawners:* There are no steelhead hatchery programs operated within the John Day River basin, therefore this metric is rated as **very low risk**.

The overall rating for the spawner composition metric is **high risk**, due to the high proportion of out-of-DPS strays that spawn naturally in this population**.**

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution of the Middle Fork population encompassed four ecoregions, with the John Day Clarno Highlands, John Day Clarno Uplands, and Melange being the dominant ecoregions (Figure 6). There has been little change in ecoregion distribution between intrinsic and current. All MaSAs in the intrinsic distribution are currently occupied in a similar distribution pattern (Table 3). The rating is **low risk** for this metric.

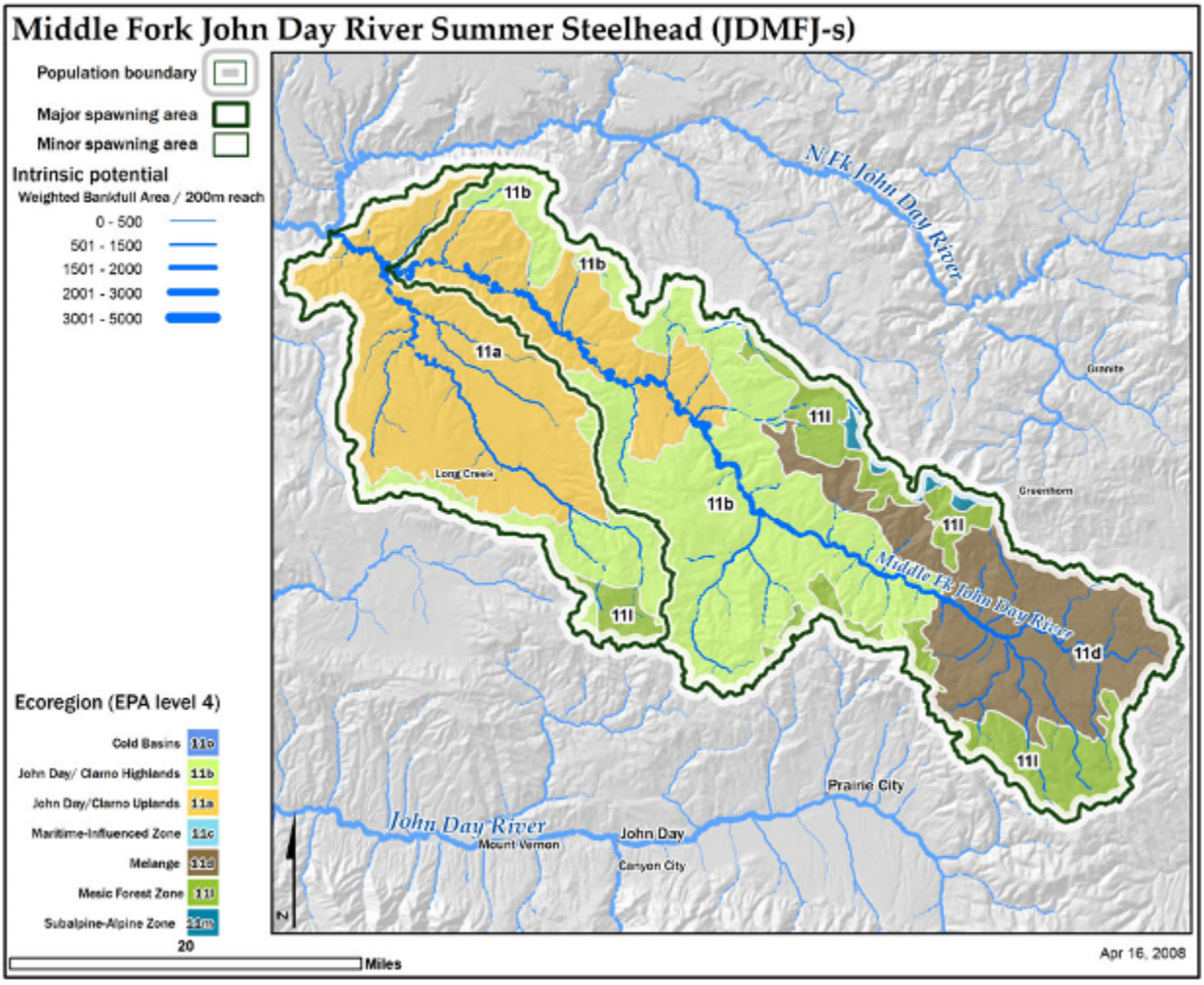


Figure 6. Middle Fork John Day River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Middle Fork John Day River summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
John Day Clarno Highlands	30.9	37.7
John Day Clarno Uplands	46.2	38.2
Melange	19.6	22.2
Mesic Forest Zone	3.3	2.0

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population crosses three dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Adult migration timing:* These dams establish a thermal barrier in the reservoirs that delays and potentially induces some mortality of migrating adults. This barrier is diminished later in the migration season. Because the timing of the barrier varies from year to year and does not develop in some years, and the degree of differential survival is likely low and not well-understood, we rate the selection intensity as low. Heritability of this trait is high, thus the hydropower rating for this trait is **moderate risk**.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is very limited tribal harvest of natural-origin fish within the John Day River subbasin; impacts from the recreational fishery are incidental to hatchery-origin fish harvest and are not selective. No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: There are no steelhead hatchery programs operated within the population; therefore, the hatchery rating is **very low risk** for all traits.

Habitat: Altered flow profiles and increased temperatures have been in place for many generations and are ongoing; there is likely some selection on juvenile and adult migration timing.

> *Adult migration timing:* Low flows in the late summer and early fall in the John Day River likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable, but a negligible proportion of the population is likely subject to these effects. Thus, the impact of habitat changes on this trait is **low risk.**
>
> *Juvenile migration timing:* Late spring and early summer temperatures are elevated relative to historical conditions. There has likely been some effect on juvenile migration timing as temperatures can reach stressful levels in the John Day River mainstem in late spring and early summer in some years. Selection intensity is considered negligible and the heritability of this trait is moderate to low. The rating for this trait is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective

predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

There is only one trait that has a moderate rating for one selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** for the Middle Fork John Day River summer steelhead population (Table 4). The rating for Goal A (allowing natural rates and levels of spatially mediated processes) was **low risk**. The current spawner distribution of the Middle Fork population mimics the intrinsic distribution. The population is distributed broadly across the landscape, in both MaSAs with adequate gaps and good continuity between spawning areas.

The rating for Goal B (maintaining natural levels of variation) was **moderate risk**. Additional genetics analyses are needed to better assess genetic variation and hatchery introgression. This population was rated high risk for proportion of out-of-DPS hatchery strays based on a limited time series of composite John Day River population data. Better population-specific spawner composition data are needed to better understand the out-of-DPS hatchery stray influence. If there is significant hatchery introgression that affects genetic variation through time, then the risk rating may increase.

Table 4. Middle Fork John Day River summer steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Low Risk
(Mean = 1.3)</td><td rowspan="3">Low Risk
(Mean = 1.3)</td><td rowspan="13">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>A.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Low Risk (1)</td><td rowspan="10">Moderate Risk
(Mean = 0.5)</td></tr>
<tr><td>B.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>L (1)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The Middle Fork John Day River summer steelhead population does not currently meet the ICTRT criteria for viable status. However, the population does meet the criteria to be rated as **MAINTAINED** (Figure 7). Overall abundance and productivity is rated at **Moderate Risk.** The 10-year geometric mean abundance of natural-origin spawners is 756, which is 76% of the minimum abundance threshold of 1,000. The 20-year geometric mean productivity (2.45 R/S; Table 6) exceeds the minimum required productivity of 1.35 R/S at the abundance threshold. Overall spatial structure and diversity is rated at **Low Risk** and the lower end of the adjusted standard error met the low risk criteria. Increased annual abundance would allow this population to achieve an abundance/productivity risk rating of low and raise the overall viability rating to viable.

Abundance/ Productivity Risk	Spatial Structure/Diversity Risk: Very Low	Low	Moderate	High
Very Low (<1%)	**HV**	**HV**	**V**	**M**
Low (1-5%)	**V**	**V**	**V**	**M**
Moderate (6 – 25%)	**M**	**M**	**M** Middle Fork John Day River	**HR**
High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. Middle Fork John Day River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Middle Fork John Day River

Data type: Redd count expansion - Index area redd counts expanded to total population estimate by applying ratio of average redd densities (samples across all areas to samples from index reaches) from EMAP surveys. Assumed 2.1 fish per redd.

Smolt-to-Adult Return rate (SAR): Mid-Columbia composite series (see *Methods*).

Table 5. Middle Fork John Day River summer steelhead population abundance and productivity data used for curve fits and R/S analysis. Bold values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1979	**337**	**1.00**	**337**	**971**	**2.88**	**1.94**	**1882**	**5.58**
1980	815	1.00	815	1749	2.15	0.50	883	1.08
1981	1318	1.00	1318	2950	2.24	0.68	2015	1.53
1982	1160	1.00	1160	3238	2.79	0.46	1480	1.28
1983	884	1.00	884	3008	3.40	0.52	1576	1.78
1984	**739**	**1.00**	**739**	**2310**	**3.13**	**0.65**	**1494**	**2.02**
1985	2373	1.00	2373	1192	0.50	0.46	547	0.23
1986	3538	1.00	3538	1028	0.29	0.94	969	0.27
1987	2899	1.00	2899	1665	0.57	2.18	3625	1.25
1988	3471	1.00	3471	1726	0.50	0.99	1710	0.49
1989	1433	1.00	1433	849	0.59	0.96	816	0.57
1990	961	1.00	961	701	0.73	2.83	1984	2.07
1991	**716**	**1.00**	**716**	**500**	**0.70**	**2.33**	**1166**	**1.63**
1992	2851	0.99	2810	497	0.17	1.88	935	0.33
1993	816	0.99	805	497	0.61	1.18	587	0.72
1994	1008	0.97	981	737	0.73	1.07	789	0.78
1995	**480**	**0.94**	**450**	**1016**	**2.12**	**1.23**	**1245**	**2.59**
1996	**604**	**0.93**	**564**	**1215**	**2.01**	**1.03**	**1254**	**2.08**
1997	**460**	**0.95**	**436**	**1769**	**3.84**	**0.76**	**1350**	**2.93**
1998	**477**	**0.96**	**457**	**1762**	**3.69**	**0.49**	**864**	**1.81**
1999	965	0.98	945					
2000	1169	0.91	1066					
2001	1164	0.91	1061					
2002	2933	0.90	2639					
2003	1187	0.89	1058					
2004	1075	0.87	934					
2005	224	0.87	195					

Table 6. Middle Fork John Day River summer steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		
delimited	median	75% threshold	median	75% threshold	1987-1998	1979-1998	Nat. origin geomean
Point Est.	2.10	2.34	1.93	2.45	0.97	1.02	756
Std. Err.	0.21	0.22	0.18	0.16	0.16	0.16	0.22
count	10	7	10	7	12	20	10

Table 7. Middle Fork John Day River summer steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.17	0.24	n/a	n/a	0.43	0.70	58.2	1.15	0.21	n/a	n/a	0.62	0.27	53.5
Const. Rec	1247	162	n/a	n/a	n/a	n/a	39.8	1224	123	n/a	n/a	n/a	n/a	29.3
Bev-Holt	50	302	1284	286	0.11	0.82	42.6	50	119	1259	154	0.20	0.03	32.2
Hock-Stk	2.88	1.66	439	259	0.10	0.83	42.4	3.98	22.87	307	1763	0.20	0.05	32.1
Ricker	2.99	0.67	0.00069	0.00013	0.15	0.76	43.8	2.71	0.52	0.000626	0.000113	0.27	-0.01	37.8

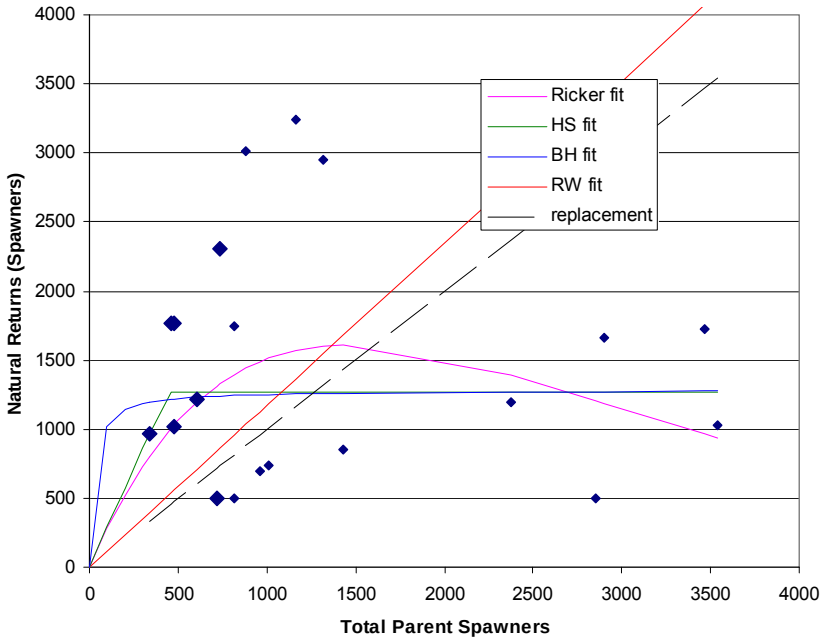


Figure 8. Middle Fork John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

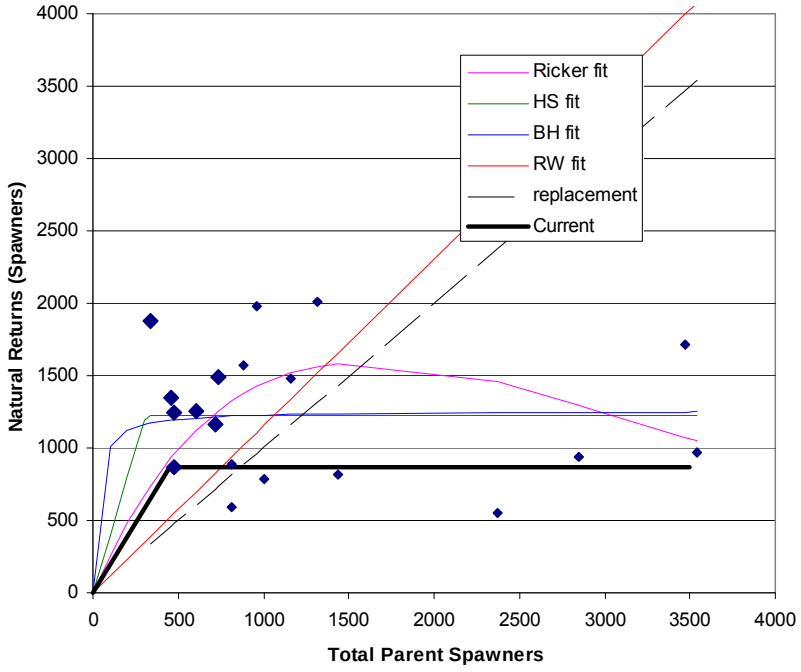


Figure 9. Middle Fork John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

South Fork John Day River Summer Steelhead Population

The South Fork John Day River summer steelhead population (Figure 1) is one of five populations in the John Day River MPG within the Mid-Columbia River DPS. All five populations in this MPG are summer run.

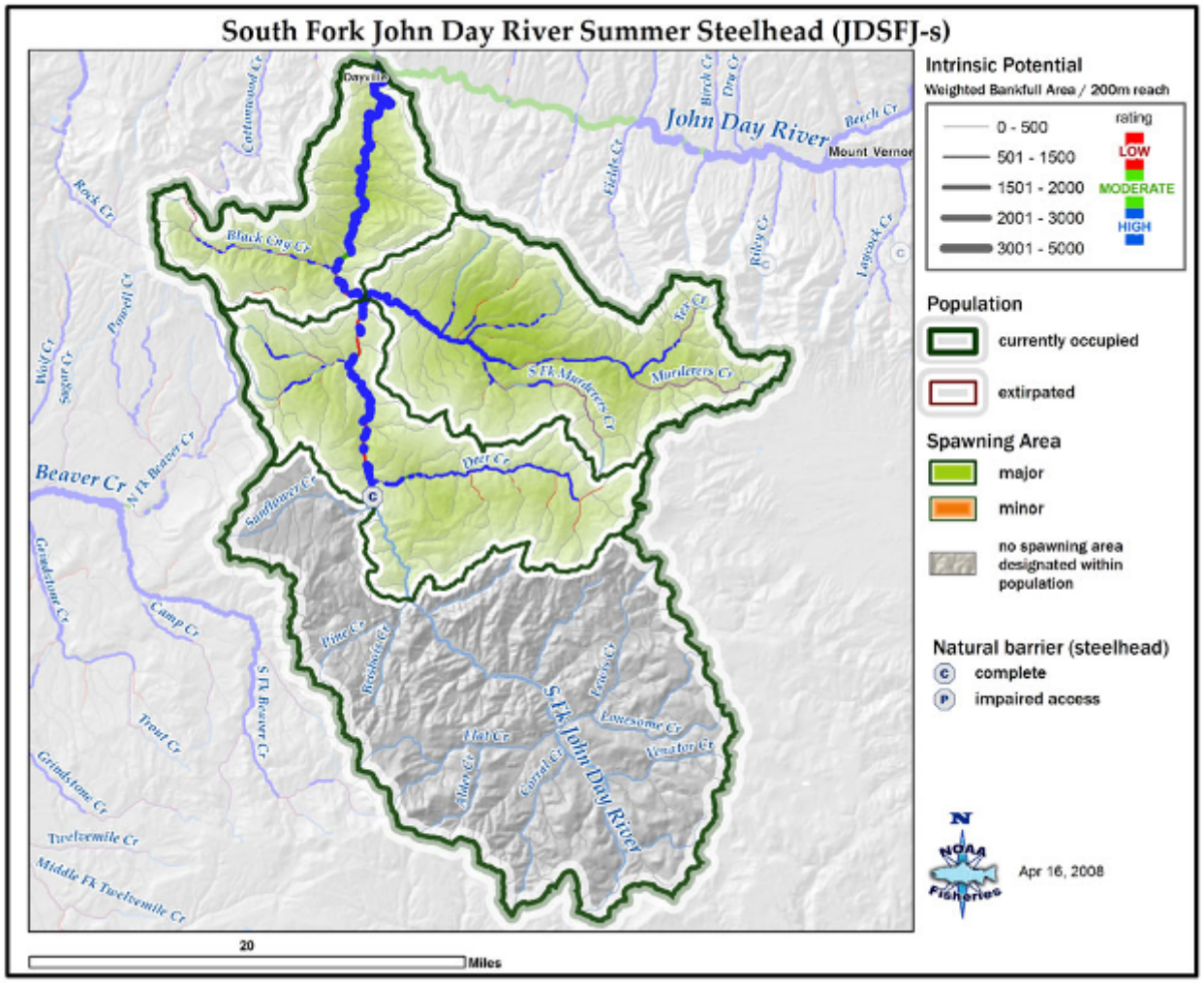


Figure 1. South Fork John Day River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the South Fork population as "basic" in size and complexity (Table 1) based on historical habitat potential (ICTRT 2007), which is the smallest population classification. A steelhead population classified as basic has a minimum abundance threshold criteria of 500 natural-origin spawners with sufficient intrinsic productivity (≥ 1.56 recruits per spawner at the minimum abundance threshold) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the South Fork population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 2.00 recruits per spawner at the minimum abundance threshold.

Table 1. South Fork John Day River summer steelhead basin statistics and intrinsic potential analysis.

Drainage area (km^2)	1,570
Stream lengths km (total) [a]	451
Stream lengths km (below natural barriers) [a]	226
Branched stream area weighted by intrinsic potential (km^2)	0.881
Branched stream area km^2 (weighted and temp. limited) [b]	0.881
Total stream area weighted by intrinsic potential (km^2)	1.030
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	1.030
Size / Complexity category	Basic / "B" (dendritic structure)
Number of major spawning areas (MaSAs)	3
Number of minor spawning areas (MiSAs)	0

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22°C.

Current Abundance and Productivity

Current (1960-2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 105 in 1999 to 2,454 in 1962 (Figure 2). Abundance estimates are based on expanded redd counts. Index surveys of steelhead redds from the Oregon Department of Fish and Wildlife (ODFW), John Day District, were used for the historical dataset. We used index surveys that showed relatively consistent visitation through the years. Survey data from Black Canyon, Deer, upper Murderer's, lower Murderer's, Tex, and Wind creeks were used in the analyses. The current spawning distribution was used for the miles of available habitat within each population's range. The index redd densities were then multiplied by a correction factor based on the ratio of index densities to EMAP (Environmental Monitoring and Assessment Program) densities for 2004-2005. The ratio was consistent for these years (0.36, 0.35). The estimated redd density for the entire spawning area (0.355 x index density) was multiplied by the total miles of currently utilized spawning habitat. Total annual redds were converted to fish by multiplying the total annual number of redds by the number of fish per redd. An average ratio of 2.1 fish per redd was developed from Deer Creek survey data in the Grande Ronde River basin. The ratio is an average from four years of data of complete and repeated surveys (censuses) of redds above a weir where we have a complete count.

The hatchery-origin/natural-origin composition of spawners were computed separately for the Lower Mainstem John Day River population, and combined for all other populations in the John Day River MPG. Data used to represent the South Fork population included observations of positively identified adipose fin-clipped spawners (1992-present) from spawning survey observations in the four populations above the Lower Mainstem, and observations from rotary screw trap and seine collections of adults (2000-present). There is evidence from the Deschutes River that hatchery straying was substantially lower before 1992, and since the source of strays in the John Day River subbasin is the same as in the Deschutes River, we assumed a similar trend. No other data are available for earlier years so the hatchery fraction was set at zero. Age composition was derived from scale readings of creel sampled unmarked fish collected during the 1980s from locations above Tumwater Falls.

Recent year natural spawners include recruits originating from naturally spawning parents and a small fraction of strays from the Snake and Columbia River hatchery programs. Since documentation of hatchery strays began in 1992, spawners originating from naturally spawning parents have comprised an average of 93%, ranging from 87% to 99%.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 259 (Table 2). During the period 1961-1998, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the South Fork John Day River ranged from 0.20 in 1987 to 13.54 in 1968. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 20-year (1979-1998) geometric mean productivity was 2.06 R/S, adjusted for SAR and delimited at 75% (375 spawners) of the abundance threshold.

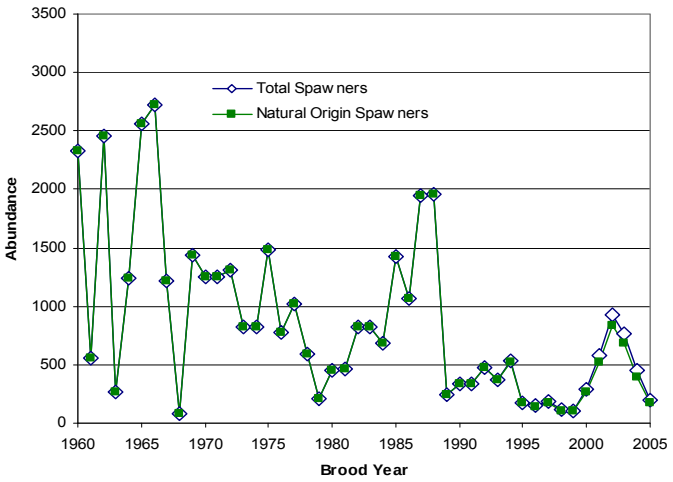


Figure 2. South Fork John Day River summer steelhead population spawner abundance (1960-2005).

Table 2. South Fork John Day River summer steelhead population abundance and productivity.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	259	(76-2729)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.93	(0.87-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (20-year R/S, SAR adjusted & delimited) [a]	2.06	(1.26-3.38)	0.27
Productivity (20-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	0.95	(0.91-1.09)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	0.98	(0.74-1.32)	0.44
Population growth rate (λ): Hatchery effectiveness = **0.0**	0.99	(0.74-1.33)	0.47

a. Delimited productivity excludes any recruit/spawner pair where the spawner number >75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The South Fork John Day River population is at **Moderate Risk** based on current abundance and productivity. The point estimate resides between the 5% and 25% viability curves (Figure 3). The lower bound of the adjusted standard error for both the productivity and abundance extend below the 25% risk level.

The average trend in abundance over the most recent 20 years has been below 1.0 based on both the trend in natural-origin spawner abundance and the population growth rate metrics (Table 2). The pattern in returns from 1980 through 2005 is similar to the pattern for several other Mid-

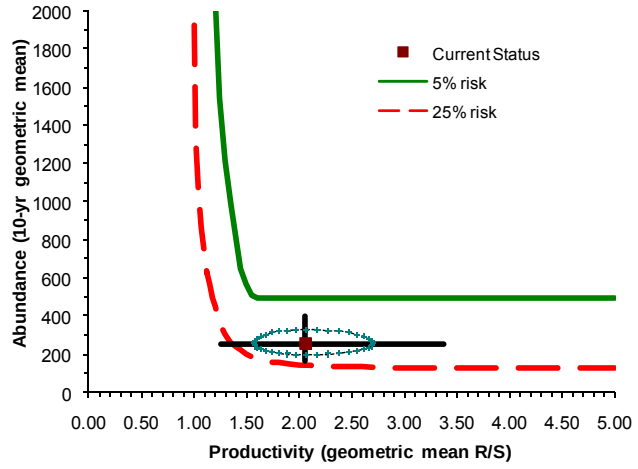


Figure 3. South Fork John Day River summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

Columbia DPS steelhead populations—generally high returns in the mid-1980s, increasing trend beginning in 2000, followed by an abrupt decline in the most recent years. The estimated proportion of hatchery-origin spawners for this population has been relatively low. Therefore the alternative estimate of population growth rate (assuming that hatchery spawners are not contributing as parents to natural production) is slightly higher than, but similar to, the standard estimate. The data series for South Fork John Day steelhead abundance extends back to 1960. Spawning levels in the 1970s were generally higher than levels observed from 1980 through 2005.

Spatial Structure and Diversity

The ICTRT has identified three major spawning areas (MaSAs) and no minor spawning areas (MiSAs) within the South Fork John Day River steelhead population (Figure 4). A natural barrier at Izee Falls limits distribution in the mainstem South Fork John Day River. Spawning is distributed broadly throughout the population boundaries including mainstem areas in the South Fork John Day River, Murderers Creek, and Canyon Creek, as well as many tributaries. Spawners within the South Fork population are primarily natural-origin fish; however, out-of-DPS hatchery fish, primarily from Snake River stocks, are present in the South Fork population.

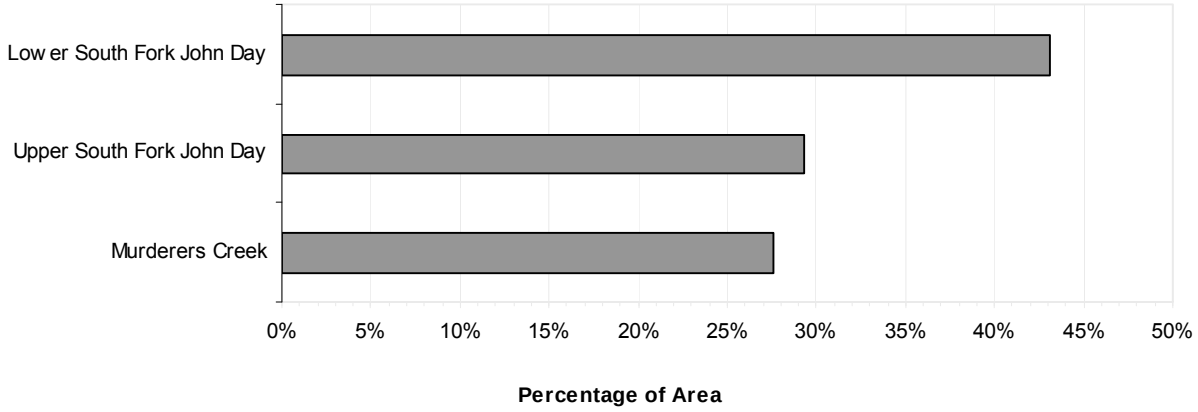


Figure 4. South Fork John Day River summer steelhead population distribution of intrinsic potential habitat across major spawning areas (MaSAs). No minor spawning areas present.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The South Fork John Day River has three MaSAs which are distributed in a dendritic pattern. Intrinsic potential is distributed relatively equally between the three MaSAs in the lower mainstem South Fork, Murderer's Creek, and the upper South Fork. Based on the ODFW spawner distribution database, all of the spawning reaches identified within the intrinsic potential distribution are currently occupied, and 247 km of habitat are presently used for spawning (Figure 5). The South Fork population rates at **low risk** for this metric because all three MaSAs are occupied.

A.l.b. Spatial extent or range of population

The current spawning distribution based on the ODFW distribution database mirrors the historical distribution represented by the intrinsic potential analyses. All MaSAs are currently occupied (Figure 5). The South Fork population is rated **very low risk** for spatial extent and range criteria. Index area spawning surveys are conducted in five creeks, including at least one reach in each MaSA. Recent spawning ground surveys results will be analyzed for future viability assessments.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There has been no increase or decrease in gaps between spawning areas. Spawning habitat connectivity appears to be unchanged within the South Fork population. The South Fork population rates at **very low risk** for gaps and connectivity.

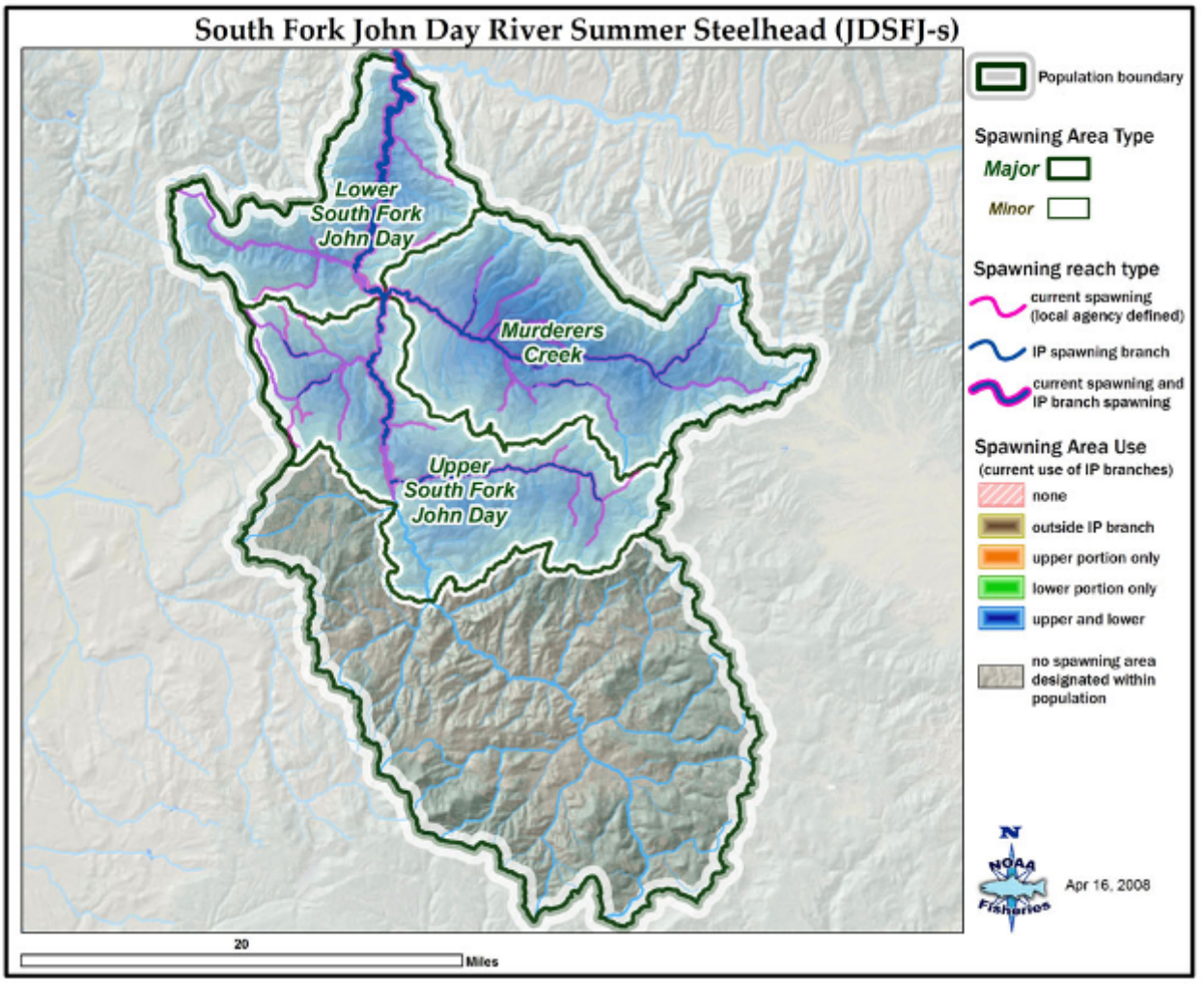


Figure 5. South Fork John Day River summer steelhead population current spawning distribution and spawning area occupancy designations.

There are no direct observations to evaluate current life history strategies relative to historic; therefore we infer loss of life history diversity based on habitat changes. Increased water

temperatures have likely reduced connectivity and quantity of habitats available during summer, but have not likely resulted in loss of any major life history strategies. Juvenile steelhead currently exhibit diverse patterns of movement to and from tributaries and mainstem reaches throughout the life cycle. These diverse movement patterns result in rearing in a diversity of habitat types. South Fork John Day River steelhead are A-run with predominant smolt age-at-migration of age 2 and age 3 and return primarily after one or two years in the ocean. These characteristics are typical for summer run steelhead in the Columbia River basin. Evidence does not indicate loss of any major life history strategies, thus the population rates at **low risk** for this metric**.**

B.1.b. Phenotypic variation

We have no data to assess if any phenotypic traits have been significantly changed or lost. Although habitat conditions are altered from historic conditions the types of alterations would not result in loss of significant phenotypic traits. Due to water temperature changes in the mainstem Columbia River and John Day River, there have likely been reductions in the variation of adult migration timing and some reduction in distribution of summer rearing. There are no other major selective pressures which would cause significant changes or loss of traits. The South Fork population rates at **low risk** for phenotypic variation.

B.1.c. Genetic variation

There are limited genetics data for John Day River steelhead populations and only one sample from the South Fork population. The South Fork population shows greater between-population divergence than the other John Day River samples. Overall, the John Day River samples were not well differentiated. Samples were taken from a relatively small geographic area over a short timeframe. There is no biological basis for the low level of differentiation. Past genetic samples were likely taken prior to potential significant hatchery influence. For the genetic variation metric, we have assigned a level of **low risk** to the South Fork population. This rating reflects a balance between apparent similarity between populations in the John Day River MPG and some degree of differentiation. Samples were collected from multiple locations in 2005 and will be analyzed in the near future to better inform the genetic variation risk assessment.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners:* There are inadequate data to estimate the out-of-DPS hatchery fraction specifically for the South Fork population. Estimates we used in this assessment were based on data from a composite of four John Day River populations (South Fork, Middle Fork, North Fork and Upper Mainstem). These estimates are based on observations from spawning surveys and kelt collections. Since 1992 the estimate hatchery fraction has ranged from 0.01-0.13 with a mean of 0.067. Based on coded wire tags (CWTs) recovered primarily from recreational fisheries, most of the strays are from Snake River hatcheries. Given the level and duration of strays, the population rated at **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS:* There have been a total of four fish with CWTs recovered in the John Day River from out-of-MPG within-DPS origin. Three originated from

the Umatilla Hatchery program and one from the Deschutes. It appears very few within-DPS hatchery fish stray into the John Day River MPG, thus the rating is **low risk**.

(3) *Out-of-population spawners from within the MPG:* There are no steelhead hatchery programs operated within the John Day River basin, and this metric is rated as **very low risk**.

(4) *Within-population hatchery spawners*. There are no steelhead hatchery programs operated within the John Day River basin, therefore this metric is rated as **very low risk**.

The overall rating for spawner composition is **high risk** due to the high proportion of out-of-DPS strays that spawn naturally in this population**.**

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution of the South Fork population encompassed five ecoregions, with the John Day Clarno Uplands being predominant. The current distribution is nearly identical to the intrinsic distribution (Figure 6 and Table 3), thus we have rated this population at **low risk** because only two of the ecoregions contain greater than 10% of the historic distribution.

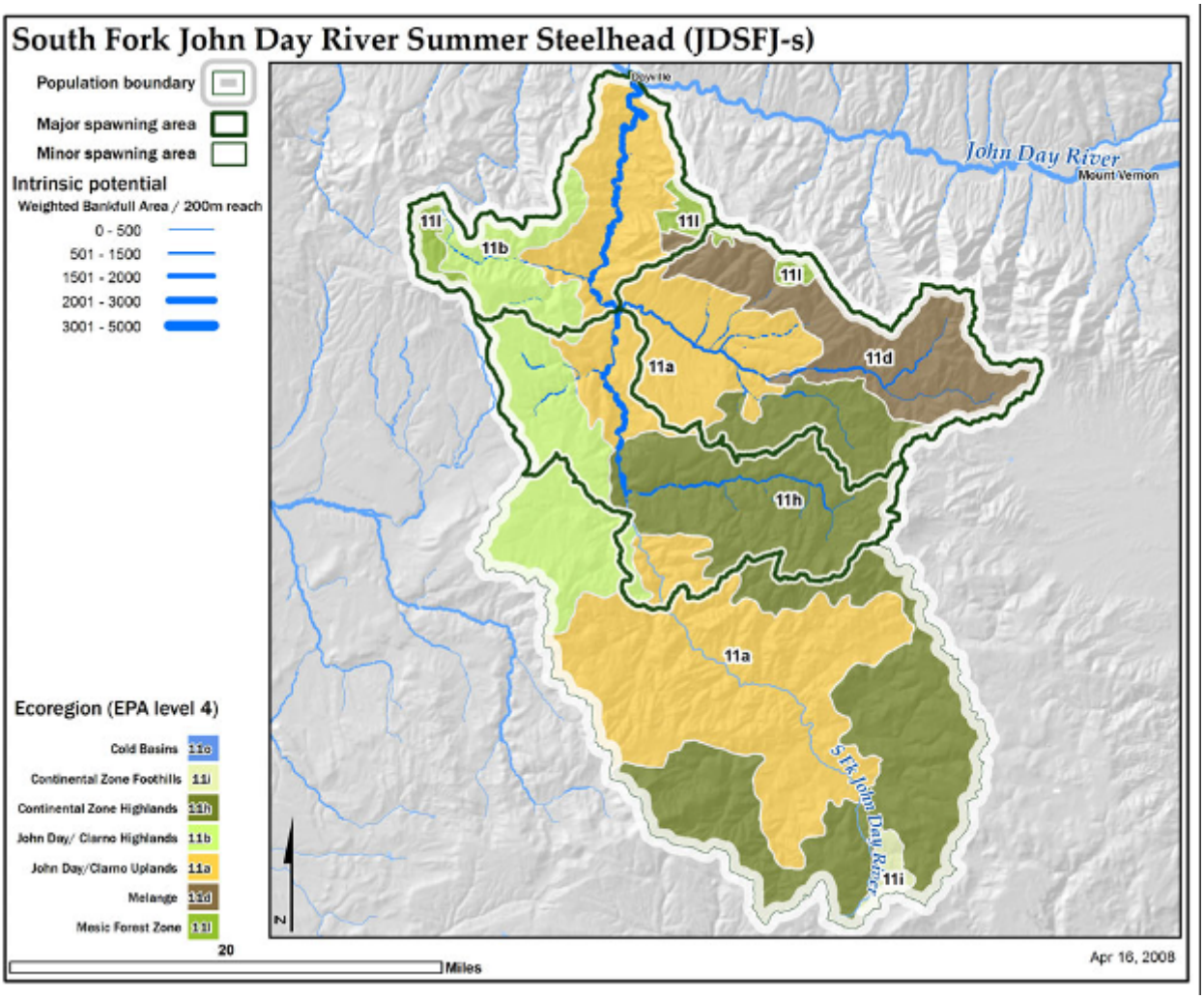


Figure 6. South Fork John Day River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. South Fork John Day River summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Continental Zone Highlands	16.7	16.4
John Day Clarno Highlands	3.4	3.4
John Day Clarno Uplands	69.9	70.2
Melange	9.9	9.9
Mesic Forest Zone	0.1	0.1

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes three dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Adult migration timing*: These dams establish a thermal barrier in the reservoirs that delays and potentially induces some mortality of migrating adults. This barrier is diminished later in the migration season. Because the timing of the barrier varies from year to year and does not develop in some years, and the degree of differential survival is likely low and not well-understood, we rate the selection intensity as low. Heritability of this trait is high, thus the hydropower rating for this trait is **moderate risk**.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is very limited tribal harvest of natural-origin fish within the John Day River subbasin; impacts from the recreational fishery are incidental to hatchery-origin fish harvest and are not selective. No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: There are no steelhead hatchery programs operated within the population; therefore, the hatchery rating is **very low risk** for all traits.

Habitat: Altered flow profiles and increased temperatures have been in place for many generations and are ongoing; there is likely some selection on juvenile and adult migration timing.

> *Adult migration timing:* Low flows in the late summer and early fall in the John Day River likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable, but a negligible proportion of the population is likely subject to these effects. Thus, the impact of habitat changes on this trait is **low risk.**
>
> *Juvenile migration timing:* Late spring and early summer temperatures are elevated relative to historical conditions. There has likely been some effect on juvenile migration timing as temperatures can reach stressful levels in the John Day River mainstem in late spring and early summer in some years. Selection intensity is considered negligible and the heritability of this trait is moderate to low. The rating for this trait is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective

predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

There is only one trait that has a moderate rating for one selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** (Table 4) for the South Fork John Day River population. The rating for Goal A (allowing natural rates and levels of spatially mediated processes) was **very low risk**. Although the current spawner distribution mimics the intrinsic distribution, only three MaSAs exist within the population. Good continuity exists between spawning areas and gaps between areas have remained relatively unchanged.

The rating for Goal B (maintaining natural levels of variation) is **moderate risk**. As is the case for all John Day River steelhead populations there is uncertainty in ratings of metrics "genetic variation" and "proportion of spawners that are out-of-DPS strays." We have limited genetics data for South Fork steelhead to determine if the current population variation is similar to historic conditions and to examine the degree of hatchery fish introgression. The metric for proportion of out-of-DPS strays rated as high risk. However, the analyses relied on composite data from four John Day River populations. Additional population-specific spawner composition data are needed to better inform the risk rating and to reduce the associated uncertainty.

Table 4. South Fork John Day River summer steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Very Low Risk
(Mean = 1.67)</td><td rowspan="3">Very Low Risk
(Mean = 1.67)</td><td rowspan="13">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>A.1.c</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Low Risk (1)</td><td rowspan="9">Moderate Risk
(Mean = 0.5)</td></tr>
<tr><td>B.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>L (1)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The South Fork John Day River summer steelhead population does not currently meet the ICTRT criteria for viable status (Figure 7). However, the population does meet criteria to be rated as **MAINTAINED**. Overall abundance and productivity is rated at **Moderate Risk.** The 10-year geometric mean abundance of natural-origin spawners is 259, which is only 52% of the minimum abundance threshold of 500. The 20-year geometric mean productivity (2.06 R/S; Table 6) exceeds the minimum required productivity of 1.56 R/S at the abundance threshold. Overall spatial structure and diversity is rated at **Moderate Risk.** Improvement in abundance will allow this population to achieve viable status. There is considerable uncertainty regarding the spawner composition data. Enhanced monitoring of the hatchery-origin/natural-origin ratios on the South Fork John Day River spawning grounds should be conducted to improve the hatchery fraction estimate and reduce the degree of uncertainty.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M** South Fork John Day River	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. South Fork John Day River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells – does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – South Fork John Day River

Data type: Redd count expansion - Index area redd counts expanded to total population estimate by applying ratio of average redd densities (samples across all areas to samples from index reaches) from EMAP surveys. Assumed 2.1 fish per redd.

Smolt-to-Adult Return rate (SAR): Mid-Columbia composite series (see *Methods*).

Table 5. South Fork John Day River steelhead population abundance and productivity data used for curve fits and R/S analysis. Bold values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1979	**214**	**1.00**	**214**	**819**	**3.83**	**1.94**	**1588**	**7.43**
1980	451	1.00	451	1058	2.34	0.50	534	1.18
1981	467	1.00	467	1316	2.82	0.68	899	1.92
1982	824	1.00	824	1546	1.87	0.46	706	0.86
1983	821	1.00	821	1782	2.17	0.52	933	1.14
1984	687	1.00	687	1025	1.49	0.65	663	0.96
1985	1423	1.00	1423	290	0.20	0.46	133	0.09
1986	1069	1.00	1069	345	0.32	0.94	326	0.30
1987	1947	1.00	1947	399	0.20	2.18	868	0.45
1988	1958	1.00	1958	429	0.22	0.99	425	0.22
1989	**239**	**1.00**	**239**	**417**	**1.74**	**0.96**	**401**	**1.67**
1990	**332**	**1.00**	**332**	**325**	**0.98**	**2.83**	**920**	**2.77**
1991	**331**	**1.00**	**331**	**154**	**0.46**	**2.33**	**359**	**1.08**
1992	480	0.99	473	150	0.31	1.88	281	0.59
1993	**372**	**0.99**	**367**	**138**	**0.37**	**1.18**	**163**	**0.44**
1994	536	0.97	522	123	0.23	1.07	131	0.24
1995	**180**	**0.94**	**168**	**217**	**1.21**	**1.23**	**266**	**1.48**
1996	**145**	**0.93**	**135**	**436**	**3.01**	**1.03**	**450**	**3.10**
1997	**182**	**0.95**	**173**	**676**	**3.71**	**0.76**	**516**	**2.84**
1998	**115**	**0.96**	**110**	**719**	**6.28**	**0.49**	**353**	**3.08**
1999	105	0.98	103					
2000	288	0.91	263					
2001	576	0.91	525					
2002	922	0.90	830					
2003	761	0.89	679					
2004	452	0.87	393					
2005	197	0.87	172					

Table 6. South Fork John Day River steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		Nat. origin
delimited	median	75% threshold	median	75% threshold	1987-1998	1979-1998	geomean
Point Est.	1.72	1.66	1.95	2.06	0.96	1.14	259
Std. Err.	0.30	0.33	0.25	0.27	0.26	0.25	0.24
count	10	9	10	9	12	20	10

Table 7. South Fork John Day River steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	0.99	0.25	n/a	n/a	0.68	0.68	66.0	0.97	0.23	n/a	n/a	0.90	0.45	63.9
Const. Rec	453	82	n/a	n/a	n/a	n/a	53.0	445	66	n/a	n/a	n/a	n/a	44.8
Bev-Holt	50	0	466	0	0.18	0.85	55.8	50	233	457	89	0.37	0.40	47.6
Hock-Stk	3.99	0.13	113.60	0.72	0.18	0.85	55.8	3.09	1.42	146	71	0.36	0.41	47.5
Ricker	2.34	0.68	0.00134	0.00035	0.26	0.80	57.7	2.37	0.60	0.00140	0.00030	0.47	0.38	52.1

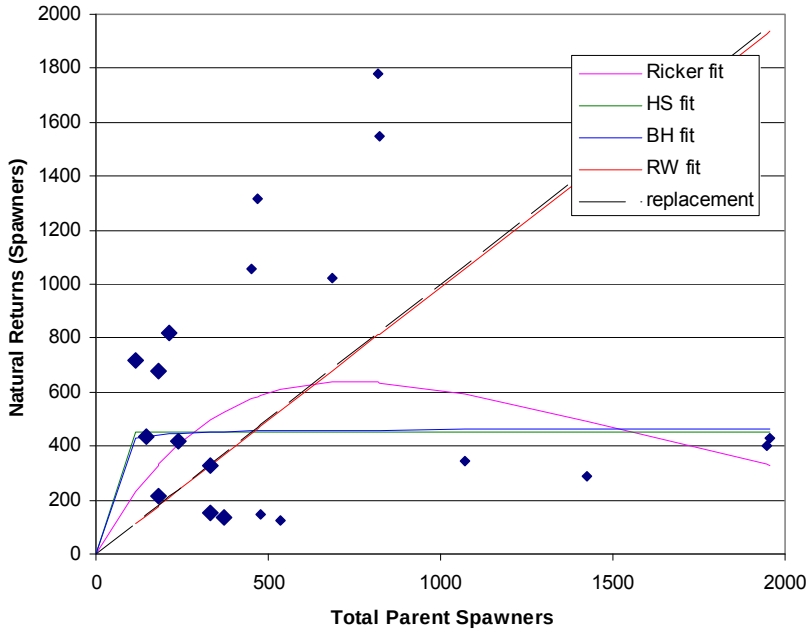


Figure 8. South Fork John Day River steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

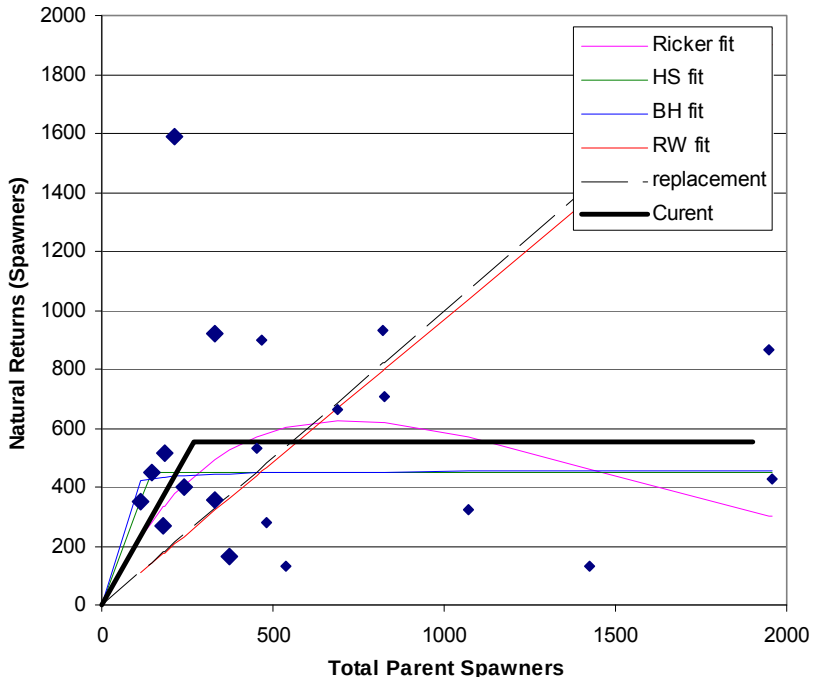


Figure 9. South Fork John Day River steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Upper Mainstem John Day River Summer Steelhead Population

The Upper Mainstem John Day River summer steelhead population (Figure 1) is one of five populations in the John Day River MPG within the Mid-Columbia River DPS. All five populations in this MPG are summer run.

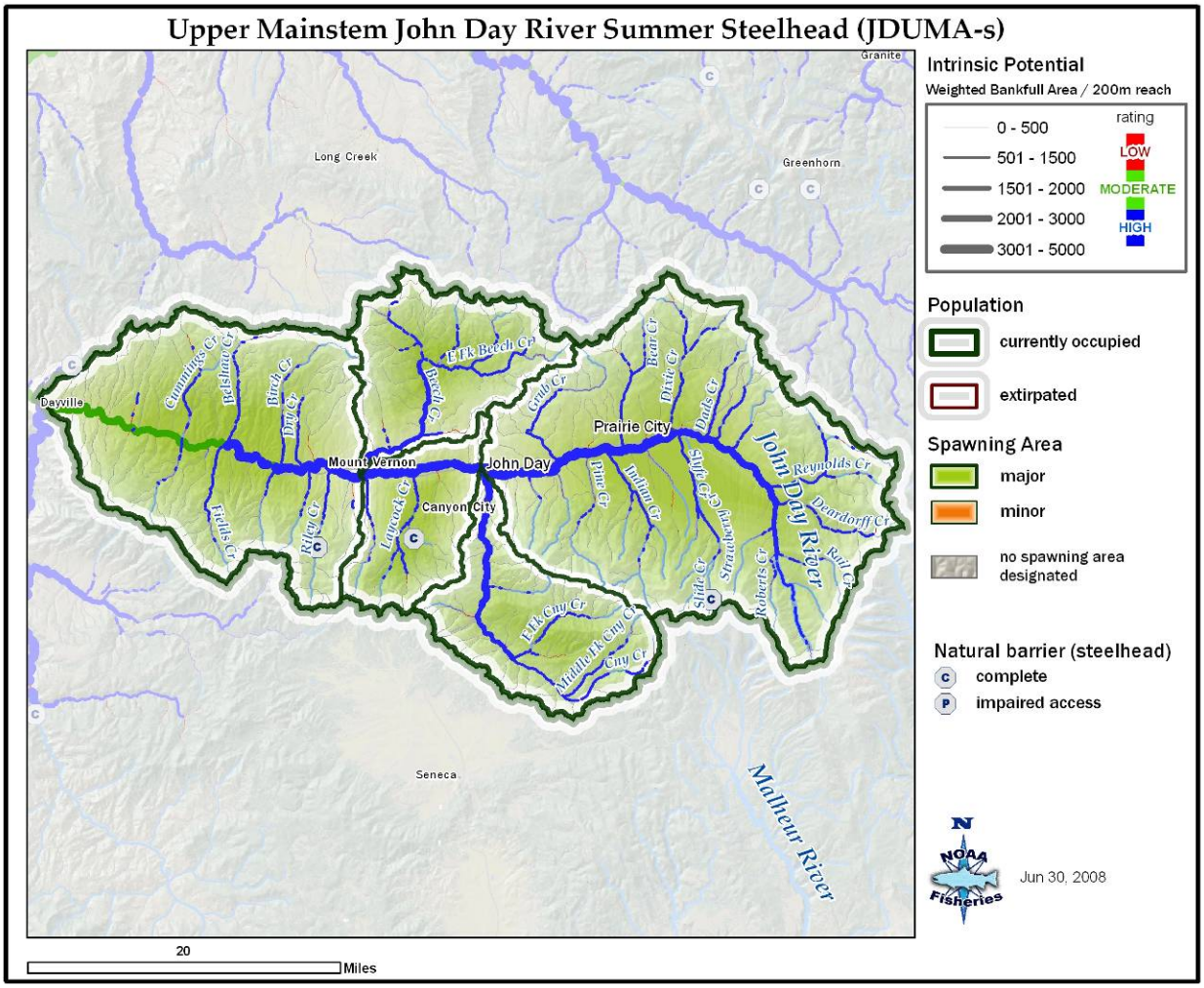


Figure 1. Upper Mainstem John Day River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Upper Mainstem John Day River population as "intermediate" in size and complexity (Table 1) based on historical habitat potential (ICTRT 2007). A steelhead population classified as intermediate has a minimum abundance threshold of 1,000 natural-origin spawners with sufficient intrinsic productivity (≥ 1.35 recruits per spawner at the minimum abundance threshold) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the Upper Mainstem population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.64 recruits per spawner at the minimum abundance threshold.

Table 1. Upper Mainstem John Day River summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	2,511
Stream lengths km (total) [a]	801
Stream lengths km (below natural barriers) [a]	767
Branched stream area weighted by intrinsic potential (km^2)	3.091
Branched stream area km^2 (weighted and temp. limited) [b]	3.091
Total stream area weighted by intrinsic potential (km^2)	3.346
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	3.346
Size / Complexity category	Intermediate / "B" (dendritic structure)
Number of major spawning areas (MaSAs)	5
Number of minor spawning areas (MiSAs)	0

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was > 22ºC.

Current Abundance and Productivity

Current (1965-2005) total spawner abundance (number of adult spawners in natural production areas) has ranged from 197 in 1995 to 4,235 in 1988 (Figure 2). Abundance estimates are based on expanded redd counts. Index surveys of steelhead redds from the Oregon Department of Fish and Wildlife (ODFW), John Day District, were used for the historical dataset. We used index surveys that showed relatively consistent visitation through years (Belshaw, Bear, Beech, East Fork Beech, Canyon, Middle Fork Canyon, McClellan, Riley, and Tinker creeks). The current spawning distribution was used for the miles of available habitat within each population's range. The index redd densities were then multiplied by a correction factor to estimate the annual redd densities for the entire spawning distribution, based on the ratio of index redd densities to EMAP (Environmental Monitoring and Assessment Program) redd densities for 2004-2005; the ratio was consistent for these years (0.36, 0.35). The estimated redd density for the entire spawning area (0.355 x index density) was multiplied by the total miles of spawning habitat currently utilized. Total annual redds were converted to fish by multiplying the total annual number of redds by the number of fish per redd. Fish per redd ratios were developed from four years of data of complete and repeated surveys (censuses) on Deer Creek in the Grande Ronde River basin of redds above a weir where there was a complete fish count; the calculated average fish per redd estimate was 2.1.

The hatchery-origin/natural-origin composition of spawners was computed separately for the Lower Mainstem John Day River population and combined for all other populations in the MPG. Data used to represent the Upper Mainstem population included observations of positively identified fin-clipped spawners (1992-present) from spawning survey observations in the four populations above the Lower Mainstem, and observations from rotary screw trap and seine collections of adults (2000-present). Evidence from the Deschutes River indicates that hatchery straying was substantially lower before 1992; because the source of strays in the John Day River subbasin is the same as in the Deschutes River we assumed a similar trend. No data are available for earlier years so the hatchery fraction was set at zero. Age composition was derived from scale readings of creel sampled unmarked fish collected during the 1980s above Tumwater Falls.

Recent year natural spawners include recruits from naturally spawning parents and a small fraction of strays from Snake and Columbia River hatchery programs. Spawners originating from naturally spawning parents have comprised an average of 93% since hatchery strays were documented in 1992. Since then, the percentage of natural spawners has ranged from 87%-99%.

Abundance in recent years has been moderately variable. The 10-year (1994-2003) geometric mean abundance of natural-origin spawners was 524 (572 total spawners). During the period 1969-1998, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Upper Mainstem John Day River ranged from 0.19 in 1992 to 5.43 in 1979. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 20-year (1979-1998) geometric mean productivity was 2.14 R/S, adjusted for SAR and delimited at 75% (750 spawners) of the abundance threshold.

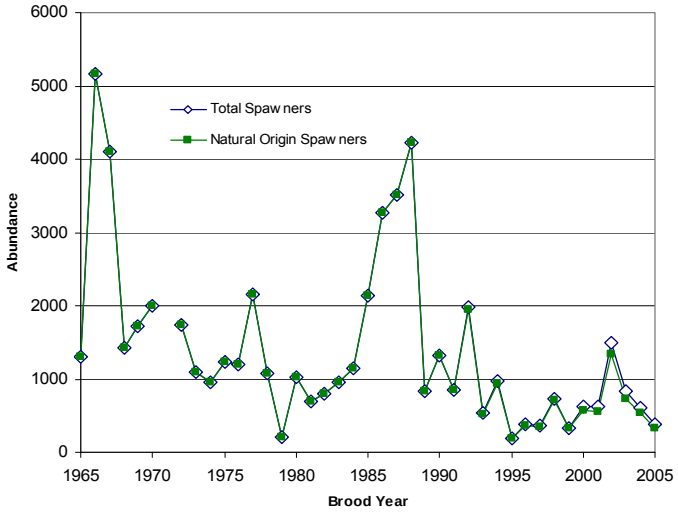


Figure 2. Upper Mainstem John Day River summer steelhead population spawner abundance (1960-2003).

Table 2. Upper Mainstem John Day River summer steelhead population abundance and productivity.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	524	(185-5169)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.93	(0.87-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (20-year R/S, SAR adjusted & delimited) [a]	2.14	(1.52-2.76)	0.33
Productivity (20-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	0.95	(0.92-1.03)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	0.99	(0.77-1.27)	0.44
Population growth rate (λ): Hatchery effectiveness = **0.0**	0.99	(0.77-1.28)	0.47

a. Delimited productivity excludes any recruit/spawner pair where the spawner number >75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Upper Mainstem John Day River population is at **Moderate Risk** based on current abundance and productivity. The point estimate for abundance and productivity resides between the 5% and 25% risk curves (Figure 3).

The average trend in abundance over the most recent 20 years has been below 1.0 based on both the trend in ln(natural-origin spawner abundance) and the population growth rate metric (λ) with no adjustment for relative hatchery-origin spawner effectiveness (Table 2). Like most Mid-Columbia DPS steelhead

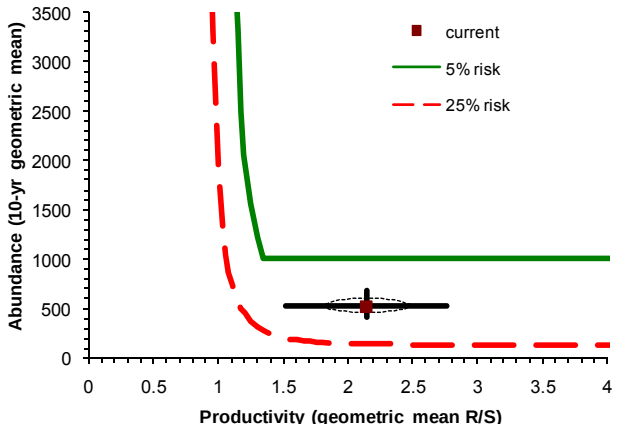


Figure 3. Figure 3. Upper Mainstem John Day River steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

populations, the estimated number of spawners in the Upper Mainstem John Day increased in the mid 1980s, and then dropped back down by the early 1990s. Annual returns since 1999 have generally been below the early 1980s levels, except for increased returns peaking in 2002. The estimated proportion of hatchery-origin spawners has been relatively constant over the period at 7% (Table 3.5.5–2). The relative effectiveness of hatchery-origin spawners in contributing to natural production in this population is not known. Setting the value to 0.0, the opposite extreme from 1.0, does not substantially alter the estimated population growth rate given the relatively low proportion of hatchery-origin spawners recorded for this population.

Spatial Structure and Diversity

The ICTRT has identified five major spawning areas (MaSAs) and no minor spawning areas (MiSAs) within the Upper Mainstem John Day River steelhead population (Figure 4). Most of the production area resides in the Upper John Day MaSA. Spawning is distributed broadly across the population including mainstem reaches in the Upper John Day River, Canyon Creek, and Beech Creek, as well as in numerous tributaries from the town of Dayville, OR, upstream to the headwaters. Spawners within the Upper John Day River are primarily natural-origin fish, although a small proportion of out-of-DPS hatchery fish, primarily from Snake River stocks, are present in the Upper Mainstem population.

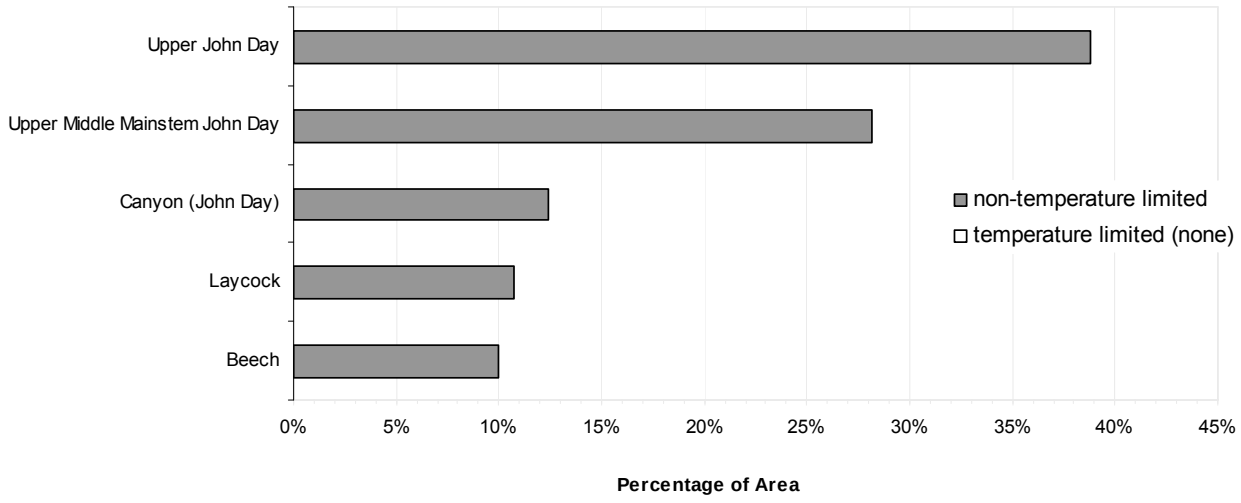


Figure 4. Upper Mainstem John Day River summer steelhead population distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs).

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Upper Mainstem John Day River population has five MaSAs (no MiSAs) which are distributed in a complex dendritic pattern. Based on the ODFW spawner distribution database all of the MaSAs are currently occupied and a total of 489 km are presently used for spawning (Figure 5). The Upper Mainstem John Day River population rates at **very low risk** because all five MaSAs are occupied in a dendritic configuration.

A.l.b. Spatial extent or range of population

All of the historical MaSAs are currently occupied (Figure 5). This population rates at **very low risk** for spatial extent and range, since greater than 90% of the historical MaSAs are occupied. There are nine spawning survey index sites in the Upper Mainstem John Day River population covering all five MaSAs. Recent survey results will be analyzed for future viability assessments.

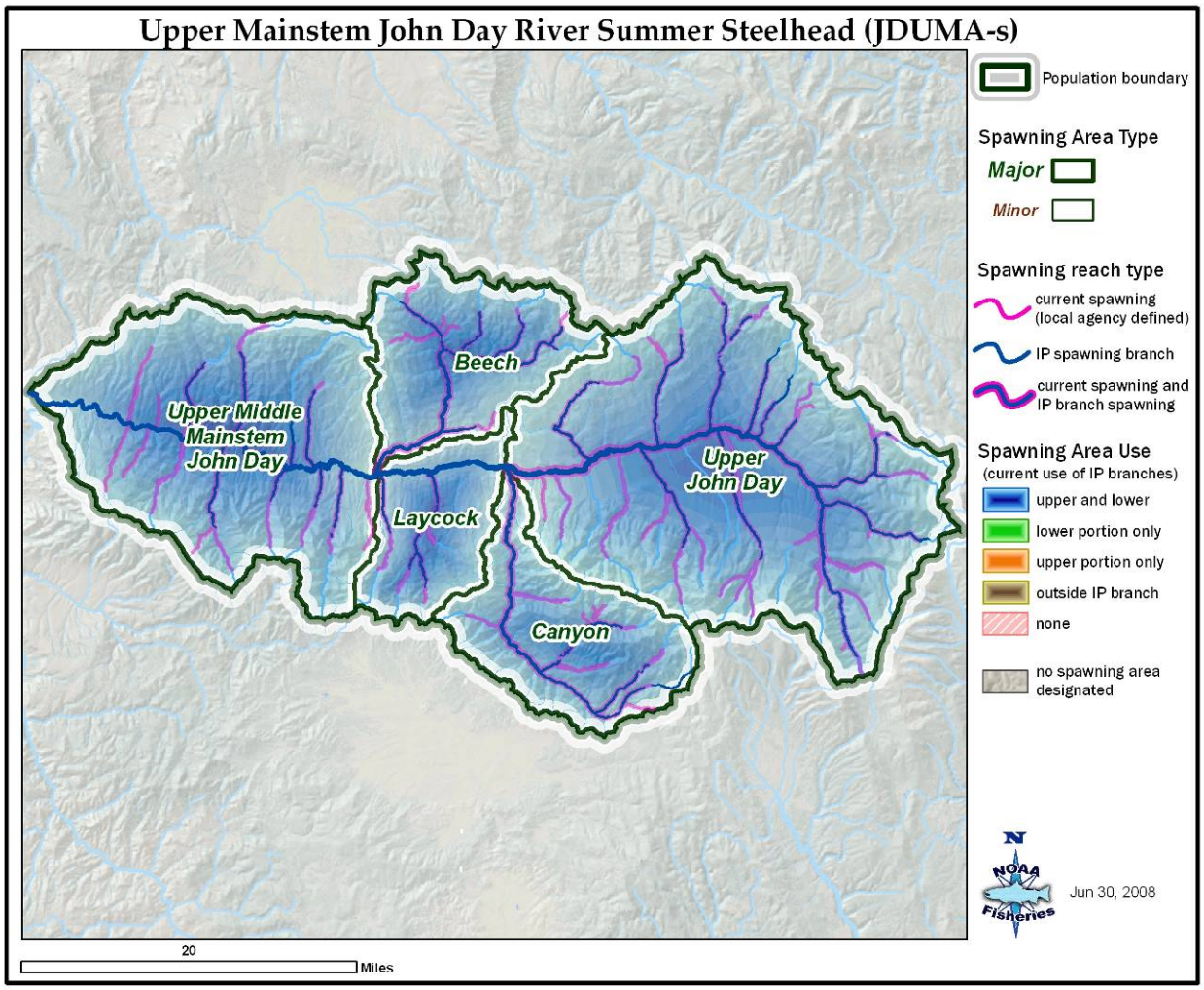


Figure 5. Upper Mainstem John Day River summer steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There have been no increases or decreases in gaps between spawning areas relative to historic distribution. Spawning connectivity appears to be unchanged, thus the population rates at **very low risk** for this metric.

B.1.a. Major life history strategies

There are no direct observations to assess loss in major life history strategies for the Upper Mainstem population; therefore we infer changes in life history from habitat information. Habitat conditions have been altered resulting in decreased flows and increased temperatures. The habitat changes limit juvenile movement patterns and rearing distribution during summer. The age-at-migration and ocean residence data are based on scale analyses from angler caught fish and represent a composite for John Day River populations. Smolt age-at-migration and ocean residence appear to be normal for A-run steelhead. There is no evidence for loss of major life history pathways. We have rated this metric as **moderate risk** because of the significant loss of summer rearing in the upper mainstem and tributaries.

B.1.b. Phenotypic variation

Mainstem Columbia River temperatures, as well as temperatures within the John Day River basin, have likely reduced the variation in both adult and juvenile migration. Warmer temperatures in the summer and autumn hinder or prevent adult movement upstream into the John Day River. Warmer temperatures in early summer have likely truncated the smolt migration timing so that fewer fish migrate at the tail end of the distribution. The reduction in these phenotypic traits results in a rating of **low risk** for the Upper Mainstem John Day River population.

B.1.c. Genetic variation

There are limited genetics data for the John Day River steelhead populations and only one sample from the Upper Mainstem population. We have no indications of past bottlenecks and the only major genetics concern is related to introgression from out-of-DPS hatchery fish. Overall the John Day River samples are not well differentiated. Samples were taken from a relatively small geographic area for only one year. We have rated the population as **low risk**. This rating is driven by balance between apparent similarity within and between populations and relative degree of differentiation. There is the need for better genetic assessment of this population to characterize genetic diversity and hatchery fish genetic introgression. Samples were collected in 2005 to provide better information for assessing genetic variation.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners*: Inadequate data exist to estimate the out-of-DPS hatchery fraction specifically for the Upper Mainstem population. Estimates we used in this assessment are based on data from a composite of the four populations (South Fork, Middle Fork, North Fork and Upper Mainstem) in the John Day River that are above the Lower Mainstem population. These estimates are based on observations from spawning surveys and kelt collections seined from the mainstem. Since 1992, the estimated hatchery fraction ranged from 0.01-0.13. The mean hatchery fraction was 0.067. Based on coded wire tags (CWTs) recovered primarily from angler caught fish, the majority of stray hatchery fish originate from Snake River hatcheries. Given that the hatchery fraction of out-of-DPS strays is estimated to be greater than 0.05 for two or more generations, the rating is **high risk** for this metric.

(2) *Out-of-MPG spawners from within the DPS*: There have been four fish with CWTs recovered in the John Day River from out-of-MPG within-DPS origin. Three originated from the Umatilla Hatchery program and one from the Deschutes. It appears very few within-DPS hatchery fish stray into the John Day River, thus the rating is **low risk** for this metric.

(3) *Out-of-population spawners from within the MPG*: There are no steelhead hatchery programs operated within the John Day River basin, and this metric is rated as **very low risk**.

(4) *Within-population hatchery spawners*: There are no steelhead hatchery programs operated within the John Day River basin, therefore this metric is rated as **very low risk**.

The overall spawner composition rating is **high risk** due to the high proportion of out-of-DPS strays that spawn naturally in this population**.**

B.3.a. Distribution of population across habitat types

The initial distribution of the Upper Mainstem population encompassed four ecoregions of which only two were greater than 10% of the distribution (Figure 6). The John Day Clarno Uplands is the dominant ecoregion. There has been very little change in ecoregion distribution as the current distribution mimics the intrinsic potential (Table 3). The risk level is **low risk** only because two ecoregions have proportions greater than 10%.

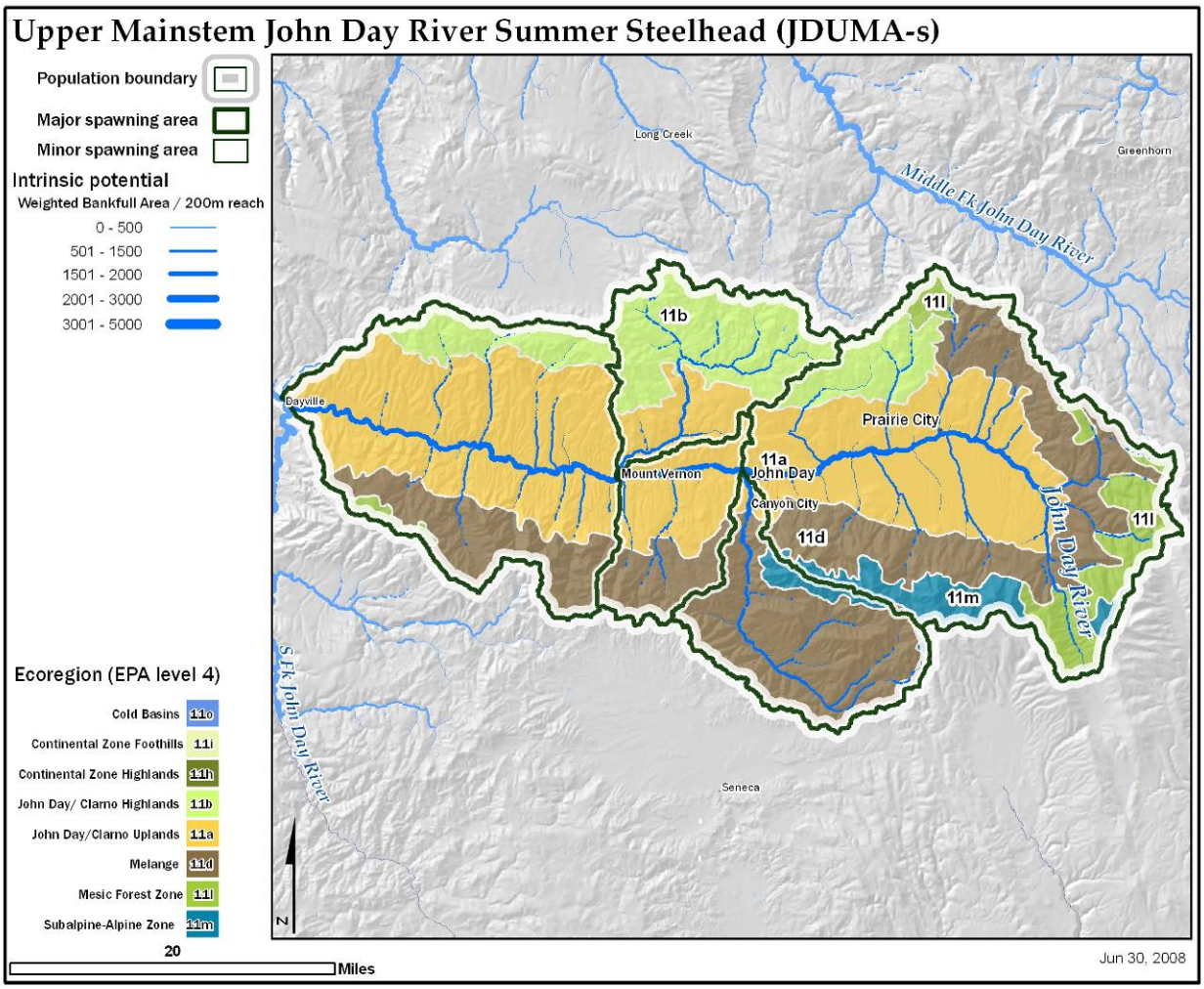


Figure 6. Upper Mainstem John Day River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Upper Mainstem John Day River summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
John Day Clarno Highlands	7.0	9.4
John Day Clarno Uplands	72.5	63.2
Melange	18.3	24.7
Mesic Forest Zone	2.2	2.7

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population crosses three dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Adult migration timing:* These dams establish a thermal barrier in the reservoirs that delays and potentially induces some mortality of migrating adults. This barrier is diminished later in the migration season. Because the timing of the barrier varies from year to year and does not develop in some years, and the degree of differential survival is likely low and not well-understood, we rate the selection intensity as low. Heritability of this trait is high, thus the hydropower rating for this trait is **moderate risk**.

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is very limited tribal harvest of natural-origin fish within the John Day River subbasin; impacts from the recreational fishery are incidental to hatchery-origin fish harvest and are not selective. No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: There are no steelhead hatchery programs operated within the population; therefore, the hatchery rating is **very low risk** for all traits.

Habitat: Altered flow profiles and increased temperatures have been in place for many generations and are ongoing; there is likely some selection on juvenile and adult migration timing.

> *Adult migration timing:* Low flows in the late summer and early fall in the John Day River likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable, but a negligible proportion of the population is likely subject to these effects. Thus, the impact of habitat changes on this trait is **low risk.**
>
> *Juvenile migration timing:* Late spring and early summer temperatures are elevated relative to historical conditions. There has likely been some effect on juvenile migration timing as temperatures can reach stressful levels in the John Day River mainstem in late spring and early summer in some years. Selection intensity is considered negligible and the heritability of this trait is moderate to low. The rating for this trait is **low risk**.

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing:* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later

out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

There is only one trait that has a moderate rating for one selective activity. Therefore, the overall selectivity rating for this population is **low risk.**

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** for the Upper Mainstem John Day River population (Table 4). The rating for Goal A (allowing natural rates and levels of spatially mediated processes) was **very low risk** since the current distribution is nearly identical to the historic distribution.

The rating for Goal B (maintaining natural levels of variation) was **moderate risk**. This risk rating was a result of a moderate rating for changes in major life history strategies. Additional genetics information needs to be assessed to determine current genetic variation and to examine for the degree of introgression of hatchery fish. The population was rated as high risk for out-of-DPS hatchery strays based on a limited time series of composite John Day River population hatchery fish observation data. Better population-specific spawner composition data are needed to better determine the out-of-DPS hatchery fraction. If there is significant hatchery introgression which affects the genetic variation of this population through time, then the risk rating for Goal B will increase, and the overall risk rating for spatial structure/diversity will increase.

Table 4. Upper Mainstem John Day River steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">Very Low Risk
(Mean = 2)</td><td rowspan="3">Very Low Risk
(Mean = 2)</td><td rowspan="14">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>A.1.c</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.1.a</td><td>M (0)</td><td>M (0)</td><td rowspan="3">Moderate Risk (0)</td><td rowspan="9">Moderate Risk (0)</td></tr>
<tr><td>B.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>L (1)</td></tr>
<tr><td>B.2.a(3)</td><td>L (1)</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

Overall Viability Rating

The Upper Mainstem John Day River summer steelhead population does not currently meet the ICTRT criteria for viable status (Figure 7). However, the population does meet criteria to be rated as **MAINTAINED**. Overall abundance and productivity is rated at **Moderate Risk.** The 10-year geometric mean abundance of natural-origin spawners is 524, which is only 52% of the minimum abundance threshold of 1,000. The 20-year geometric mean productivity (2.14 R/S; Table 6) exceeds the minimum required productivity of 1.35 R/S at the abundance threshold and the lower end of the adjusted standard error is above the 25% risk level. Overall spatial structure and diversity is also rated at **Moderate Risk** due to loss in life history diversity and high risk for spawner composition. In order for this population to achieve a viable rating, an increase in abundance is required so that abundance/productivity risk is reduced to low risk.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**		**M** Upper Mainstem John Day River	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. Upper Mainstem John Day River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Upper Mainstem John Day River

Data type: Redd count expansion - Index area redd counts expanded to total population estimate by applying ratio of average redd densities (samples across all areas to samples from index reaches) from EMAP surveys. Assumed 2.1 fish per redd.

Smolt-to-Adult Return rate (SAR): Mid-Columbia composite series (see *Methods*).

Table 5. Upper Mainstem John Day River steelhead population abundance and productivity data used for curve fits and R/S analysis. Bold values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1979	**215**	**1.00**	**215**	**1168**	**5.43**	**1.94**	**2265**	**10.53**
1980	1031	1.00	1031	1808	1.75	0.50	913	0.89
1981	**701**	**1.00**	**701**	**2790**	**3.98**	**0.68**	**1905**	**2.72**
1982	801	1.00	801	3470	4.33	0.46	1586	1.98
1983	964	1.00	964	3576	3.71	0.52	1873	1.94
1984	1150	1.00	1150	2419	2.10	0.65	1564	1.36
1985	2143	1.00	2143	1060	0.49	0.46	487	0.23
1986	3275	1.00	3275	1169	0.36	0.94	1102	0.34
1987	3520	1.00	3520	1315	0.37	2.18	2862	0.81
1988	4235	1.00	4235	1209	0.29	0.99	1198	0.28
1989	839	1.00	839	680	0.81	0.96	654	0.78
1990	1321	1.00	1321	545	0.41	2.83	1542	1.17
1991	853	1.00	853	281	0.33	2.33	655	0.77
1992	1979	0.99	1950	385	0.19	1.88	723	0.37
1993	**535**	**0.99**	**528**	**503**	**0.94**	**1.18**	**595**	**1.11**
1994	968	0.97	943	521	0.54	1.07	558	0.58
1995	**197**	**0.94**	**185**	**460**	**2.33**	**1.23**	**564**	**2.86**
1996	**387**	**0.93**	**361**	**641**	**1.66**	**1.03**	**662**	**1.71**
1997	**359**	**0.95**	**341**	**931**	**2.59**	**0.76**	**711**	**1.98**
1998	**736**	**0.96**	**704**	**993**	**1.35**	**0.49**	**487**	**0.66**
1999	333	0.98	326					
2000	622	0.91	567					
2001	619	0.91	564					
2002	1494	0.90	1344					
2003	828	0.89	738					
2004	617	0.87	536					
2005	375	0.87	326					

Table 6. Upper Mainstem John Day River steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		
delimited	median	75% threshold	median	75% threshold	1987-1998	1979-1998	Nat. origin geomean
Point Est.	1.78	2.23	1.73	2.14	0.93	1.01	524
Std. Err.	0.28	0.23	0.26	0.33	0.13	0.19	0.15
count	10	7	10	7	12	20	10

Table 7. Upper Mainstem John Day River steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.07	0.24	n/a	n/a	0.54	0.69	62.1	1.05	0.21	n/a	n/a	0.76	0.24	57.1
Const. Rec	1000	160	n/a	n/a	n/a	n/a	48.1	981	120	n/a	n/a	n/a	n/a	37.2
Bev-Holt	9.20	12.17	1181	325	0.11	0.88	50.2	18.52	40.52	1063	228	0.27	0.27	39.8
Hock-Stk	3.56	1.80	291	155	0.11	0.88	50.3	4.58	0.56	215	0	0.26	0.32	39.7
Ricker	2.38	0.62	0.00061	0.00015	0.24	0.75	52.6	2.15	0.48	0.00055	0.00013	0.43	0.02	47.2

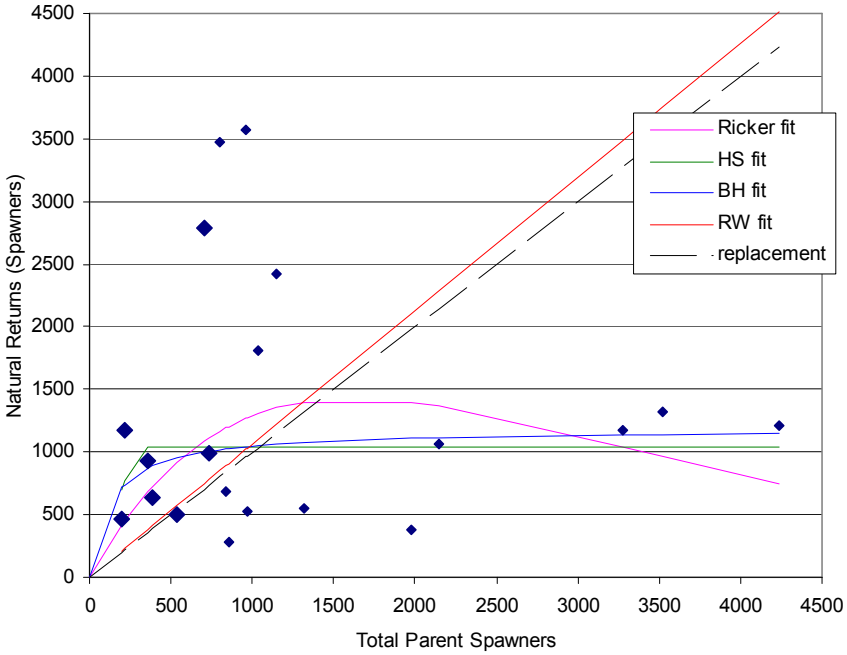


Figure 8. Upper Mainstem John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

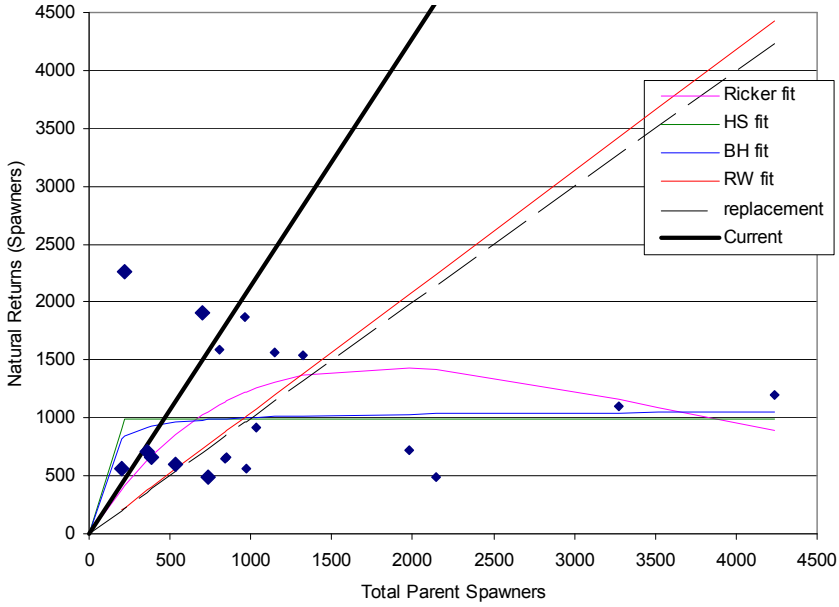


Figure 9. Upper Mainstem John Day River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Umatilla River Summer Steelhead Population

The Umatilla River summer steelhead population (Figures 1, 2) is one of three populations in the Umatilla/Walla Walla Rivers MPG within the Mid-Columbia River DPS. All three populations in this MPG are summer run.

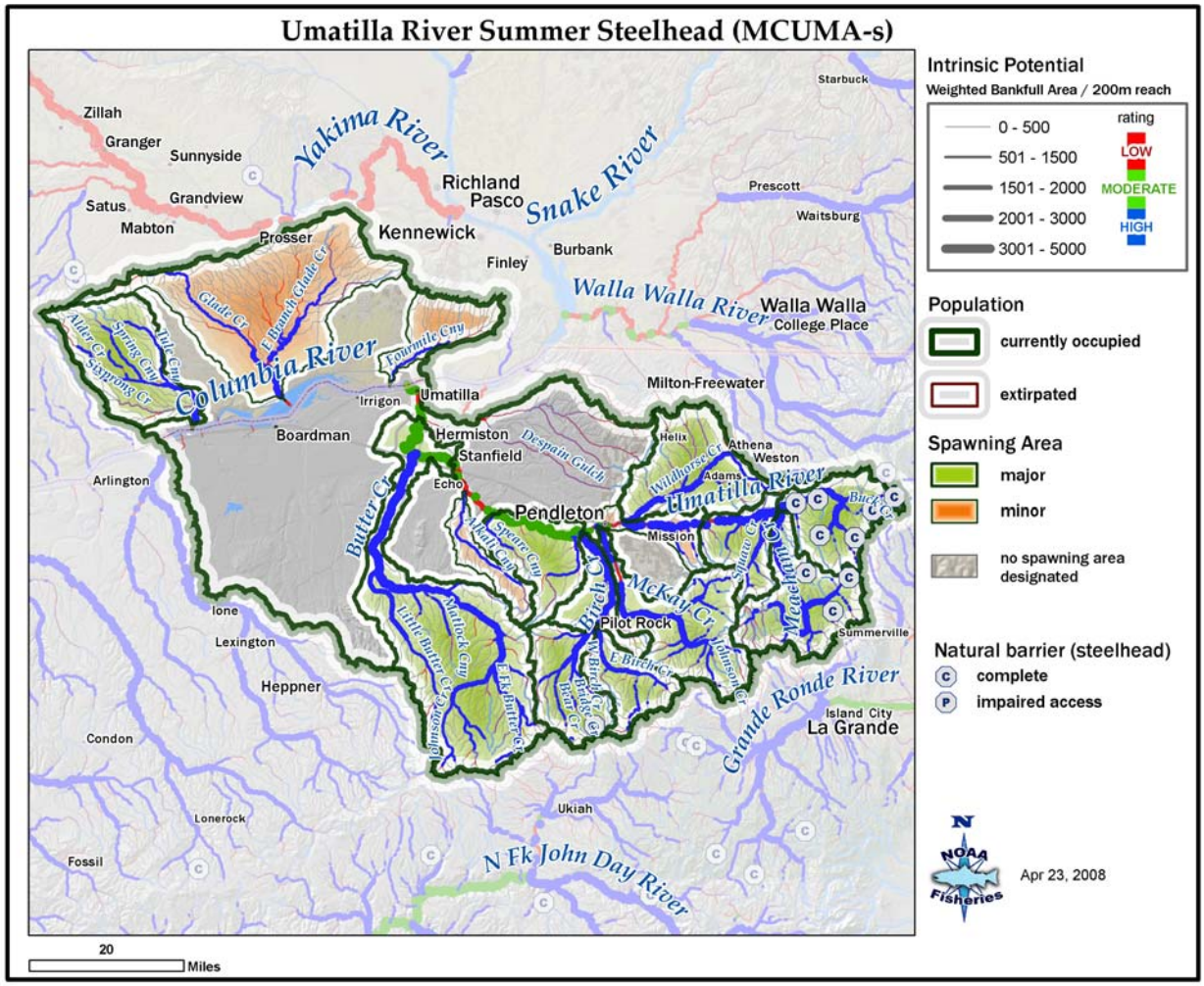


Figure 1. Umatilla River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

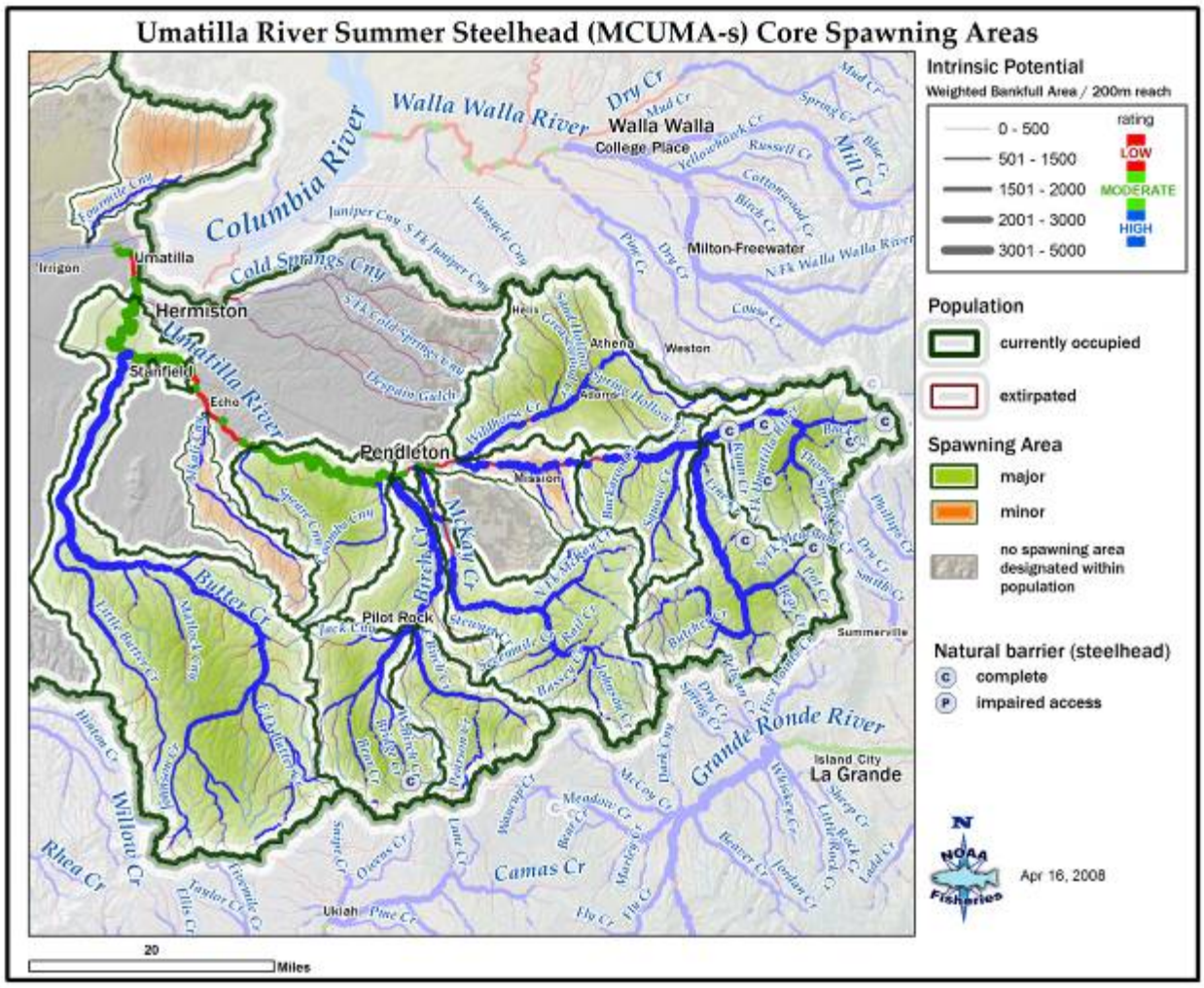


Figure 2. Umatilla River summer steelhead population boundary and core major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Umatilla River population as "large" in size and complexity (Table 1) based on historical habitat potential. A steelhead population classified as large has a mean minimum abundance threshold of 1,500 natural-origin spawners with sufficient intrinsic productivity (≥ 1.26 recruits per spawner at the minimum abundance threshold) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the Umatilla River population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.53 recruits per spawner at the minimum abundance threshold. The core production area for this population is the Umatilla River drainage (Figure 2). The population as defined by the ICTRT includes production from small, relatively isolated tributaries to the mainstem Columbia River entering downstream of the Umatilla River. Annual estimates of abundance for the downstream tributaries included as components of this population are not available. The Umatilla River drainage contains sufficient intrinsic potential habitat by itself to meet the definition of a large population. Given those considerations, the current abundance and

productivity metrics for the Umatilla River are used to characterize abundance and productivity of the population.

Table 1. Umatilla River summer steelhead basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	10,457
Stream lengths km (total) [a]	2,322
Stream lengths km (below natural barriers) [a]	2,278
Branched stream area weighted by intrinsic potential (km^2)	7.531
Branched stream area km^2 (weighted and temp. limited) [b]	7.456
Total stream area weighted by intrinsic potential (km^2)	9.070
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	3.415
Size / Complexity category	Large / "B" (dendritic structure)
Number of major spawning areas (MaSAs)	13
Number of minor spawning areas (MiSAs)	3

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where mean weekly modeled water temperature was > 22°C.

Current Abundance and Productivity

Current (1967 to 2004) total abundance (number of adult spawners in natural production areas) has ranged from 771 in 1998 to 5,172 in 2002 (Figure 3). Spawner abundance estimates for natural and hatchery summer steelhead in the entire Umatilla River Basin were determined from complete counts of adult returns to Three Mile Falls Dam (TMFD) at river mile 3.7. These counts did not include removals or mortality at and above the dam in all years except brood years (BY) 1984-1987. Fish were enumerated using electronic counters (BY 1967-1983), trapping (BY 1988-2000), and a combination of trapping and video monitoring (BY 2001-present). For BYs 1984-1987 abundance estimates were made with mark-recapture estimates. Missing abundance data for BY 1971, 1972, and 1979 were reconstructed using the known mean brood age structure from BY 1991-1998 and all available counts of brood returns in years before and after the missing counts. Counts in BY 1976 and 1978 were also incomplete but not reconstructed. In these years, electronic counters only operated from 24 December – 31 May and 13 December – 9 March, respectively. Age structure was determined by reading about 100-150 scales per year collected from adults returning in BY 1994-2004. Missing run year age structure data before BY 1994 were estimated as the BY 1994-2004 mean age structure.

Several sets of missing data for removals and mortalities at and above TMFD were estimated from the best available data. Missing harvest removals were estimated from creel survey data collected from the non-tribal fishery from BY 1993-2004 and the tribal fishery from BY 1993-2001. Harvest of hatchery fish from BY 1988-1992 was estimated as the mean percent harvest of the hatchery run passed above TMFD from the later time period (2.5% non-tribal and 6.4% tribal). All harvested fish were assumed to be natural-origin before BY 1988. For years when harvest of natural-origin fish was allowed in the non-tribal fishery (before BY 1993), harvest was estimated as mean percent catch of the natural-origin run passed above TMFD (6.8 %) (1993-2004) corrected by the mean percent of catch released (26%). Tribal harvest for BYs 1967-1987 of hatchery and natural-origin steelhead was estimated as their respective mean percent harvest of their runs passed above TMFD (6.7% of the combined natural and hatchery run passed above TMFD). Missing broodstock removals in BY 1981 and 1982 were estimated as one natural-origin fish collected for brood per 750 smolts produced based on the ratio of brood collected and smolts released in the early 1980s. All 95 hatchery fish collected for brood in BY 1991 were

assumed to have coded wire tags (CWTs) and were included in the total removal of 124 hatchery fish at TMFD for CWT recovery.

Recent year natural spawners include returns originating from naturally spawning parents, Umatilla River hatchery-origin fish and out-of-DPS spawners, primarily from the Snake River basin. Natural-origin fish have comprised an average of 73% of natural spawners since documentation of hatchery returns began in 1988. Since that time, the percentage of natural-origin spawners has ranged from 41% to 96%.

Abundance in recent years has been moderately variable. The 10-year (1995-2004) geometric mean abundance of natural-origin spawners was 1,472 (2,347 total spawners). During the period 1967-2000, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Umatilla River ranged from 0.3 in 1978 to 4.98 in 1998. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 20-year (1981-2000) geometric mean productivity was 1.50 R/S, adjusted for SAR and delimited at 75% (1,125 spawners) of the abundance threshold (Table 2).

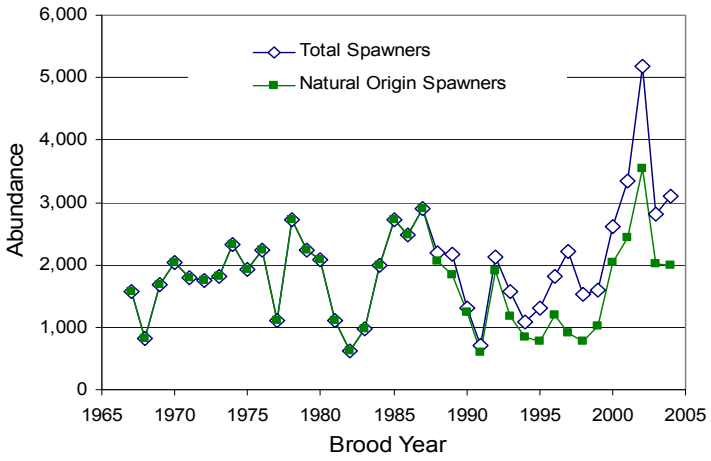


Figure 3. Umatilla River summer steelhead population spawner abundance estimates (1967-2004).

Table 2. Umatilla River summer steelhead population abundance and productivity.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	1472	(592-3542)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.73	(0.41-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (20-year R/S, SAR adjusted & delimited) [a]	1.50	(1.11-2.03)	0.15
Productivity (20-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2004)	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	1.01	(0.98-1.13)	
Population growth rate (λ): Hatchery effectiveness = **1.0**	0.99	(0.83-1.17)	0.41
Population growth rate (λ): Hatchery effectiveness = **0.0**	1.04	(0.86-1.25)	0.68

a. Delimited productivity excludes any recruit/spawner pair where the spawner number >75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.

The Umatilla River summer steelhead population is at **Moderate Risk** for abundance and productivity metrics. The productivity is at **low risk** because the point estimate is above the 5% risk level and the adjusted standard error is above the 25% risk level. Abundance is at **moderate risk** because the point estimate is slightly below the 5% risk level (Figure 4).

The trend in annual spawner abundance has been slightly positive since 1983; the population growth rate metric with no adjustment for relative hatchery effectiveness is 0.99. Annual variations in the estimated annual numbers of

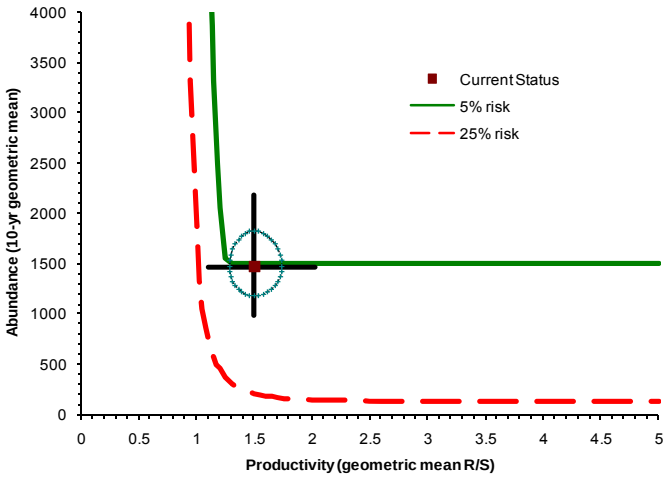


Figure 4. Umatilla River summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

steelhead spawners in the Umatilla River fluctuated considerably over the 1980-2005 period. The general timing of peaks and declines in annual spawning numbers is similar to many other Mid-Columbia DPS steelhead populations—peak in the mid-1980s, increasing returns beginning in 2000 followed by an abrupt decline to early 1980s levels. The relative effectiveness of hatchery-origin spawners in this basin is not known. Hatchery proportions on the spawning grounds have averaged 27% over the recent period. As a sensitivity analysis, we recalculated the recent average population growth rate after setting the assumed relative hatchery effectiveness value to 0.0. The average population growth rate generated from the sensitivity model run was 1.04.

Spatial Structure and Diversity

The ICTRT has identified 13 historic major spawning areas (MaSAs) and 3 minor spawning areas (MiSAs) within the Umatilla River summer steelhead population. In addition, two MaSAs (Alder Creek and Glade Creek) and one MiSA (Fourmile Canyon) are direct tributaries to the Columbia River on the Washington side and were included in the Umatilla River population. We do consider these areas in the assessment of spatial structure/diversity for the Umatilla River steelhead population (Figure 5). Current spawning distribution is somewhat limited relative to historic and is concentrated in Birch Creek, Iskulpa Creek, Meacham Creek, Upper Umatilla River, and the North and South Forks of the Umatilla River. There is documented recent year spawning in both Glade Creek and Alder Creek subbasins (Yakama Indian Nation Fisheries Program 2005); however, we are uncertain if the distribution of spawners and the frequency of use meet the occupancy criteria.

Spawners within the Umatilla River population include natural-origin returns, hatchery-origin returns of Umatilla River origin broodstock, and hatchery strays primarily originating from the Snake River basin. Hatchery-origin fish comprise a significant proportion of the naturally spawning fish in most recent years.

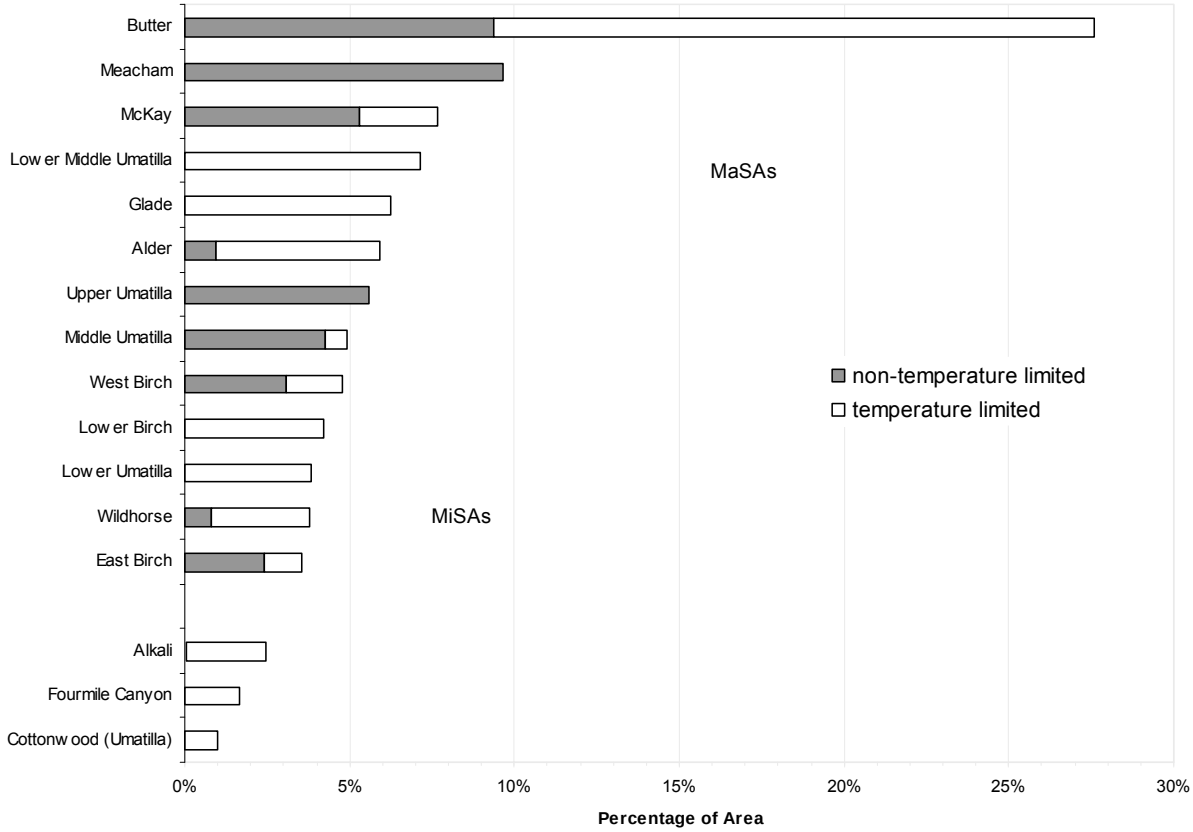


Figure 5. Umatilla River summer steelhead distribution of intrinsic potential habitat across major (MaSAs) and minor spawning areas (MiSAs). White bars represent current temperature limited areas that could potentially have had historical temperature limitations.

Factors and Metrics

A.1.a. Number and spatial arrangement of spawning areas

The Umatilla River population has 13 MaSAs and 3 MiSAs which are distributed in a complex dendritic pattern. Historically the major production areas included Butter Creek, Meacham Creek, McKay Creek, Iskulpa Creek, Birch Creek, and the middle and upper Umatilla River. Spawning distribution has been reduced significantly from the intrinsic historic distribution. Currently 8 of the 13 MaSAs are occupied. The Butter Creek, Lower Umatilla, Lower Middle Umatilla, and McKay MaSAs are unoccupied. One of the three MiSAs is currently occupied (Cottonwood Creek). Figure 6 shows both Alder and Glade MaSAs as unoccupied; however, recent information indicates that these MaSAs may be occupied. The map has not been updated because the actual spawner distribution has not been determined. Although there has been a significant reduction in spawner distribution, the Umatilla River population rates at **low risk** because it has more than four occupied MaSAs in a dendritic configuration. We have rated this metric as low risk instead of very low risk because of the uncertainty in occupancy of the Alder and Glade MaSAs.

A.l.b. Spatial extent or range of population

The current spawner distribution is reduced substantially from the intrinsic distribution. Based on the Oregon Department of Fish and Wildlife (ODFW) spawner database and the Washington Department of Fish and Wildlife (WDFW) information, 8 of 13 (61.5%) MaSAs are currently occupied and only 1 of 3 (33.3%) MiSAs is occupied (Figure 6). The spatial extent and range of spawning distribution has been reduced to an extent that this population rates as **moderate risk** for this metric. There are 12 index area spawning survey sites in the Umatilla River population. Recent survey results will be analyzed for use in future viability assessments.

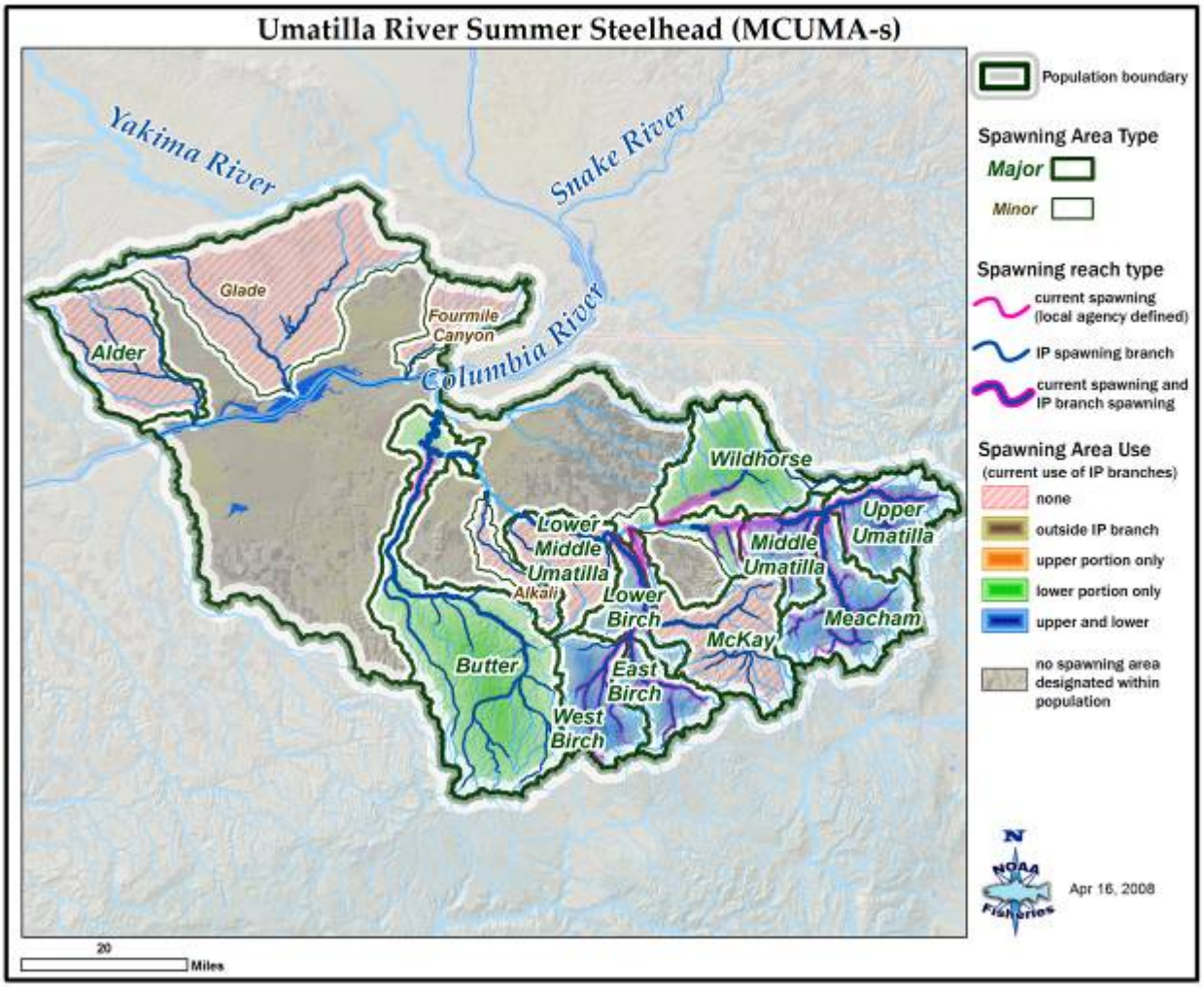


Figure 6. Umatilla River summer steelhead population current spawning distribution and spawning area occupancy designations.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There has been a change in gaps and continuity as a result of the loss of spawning in the McKay Creek and Lower Middle Umatilla River drainages as well as very limited production in the lower portion of the Butter Creek MaSA. Although some spawning occurs in lower Butter Creek, habitat conditions are such that no significant sustained production occurs. Due to the

low level of production in Butter Creek it does not serve any connectivity role within or between populations. In addition, less than 75% of the intrinsic MaSAs are currently occupied, thus the rating is **moderate risk** for this metric.

B.1.a. Major life history strategies

We have no observational data to allow any direct comparisons of historic and current life history strategies. Therefore, we have used EDT (Ecosystem Diagnosis and Treatment) analyses and habitat conditions to infer loss of life history strategies. Flow and temperature changes in the Umatilla River basin have limited movement patterns for both juvenile and adult steelhead. Juvenile steelhead cannot move into some mainstem rearing reaches above McKay Creek for over-summer rearing due to high temperatures. Adults are unable to enter the Umatilla River in early fall in many years because of the lack of flow as well as high water temperatures. Large areas, such as Butter and McKay Creek drainages, no longer support production. Flow enhancement projects have improved conditions for adult fall migration and summer rearing, particularly below McKay Creek. Past habitat changes have undoubtedly reduced diversity in life history pathways. However, it does not appear that any major pathways have been lost, and improved fall flows have provided conditions allowing adult migration throughout the fall season. The Umatilla River summer steelhead population still exhibits a diverse age structure, including multiple ages at smolt migration, multiple years of ocean residence, and repeat spawning. The population rated at **moderate risk** because all pathways exist but there has been significant reduction in variability and changes in distribution.

B.1.b. Phenotypic variation

We have no data to assess loss or substantial change is phenotypic traits, therefore we infer based on habitat changes. The changes in flow patterns and temperature profile within the Umatilla River and the mainstem Columbia River have likely resulted in reduced variation in adult and juvenile migration patterns. Juveniles have a much narrower window to successfully migrate out of the Umatilla River in the spring because water temperatures increase earlier than historically. Even though flow enhancement has improved conditions for adult fall migration, the run-timing distribution is likely truncated from historic. Adults cannot enter the river in early fall in some years because of flow and temperature limitations. We have rated the Umatilla River population at **moderate risk** because two or more phenotypic traits have changed.

B.1.c. Genetic variation

The genetics data for Umatilla River summer steelhead indicate that there is significant within-population variation between Umatilla River steelhead and other populations in the MPG (Touchet River and Walla Walla River). In addition, the within-population diversity shows no indication of impairment. The hatchery fish are similar to natural-origin fish as expected, since they are offspring of natural-origin fish. There are out-of-DPS spawners, primarily from Snake River stocks, spawning naturally in the Umatilla River basin. Given the degree of genetic variation, the Umatilla River population rated at **low risk** for this metric. Given that the genetics samples used in the analyses were collected in the mid-1980s prior to significant hatchery influence, the genetic analyses need to be updated with recent samples.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners*: A significant number of out-of-DPS spawners enter the Umatilla River. Estimates of out-of-DPS spawners are based on expanded CWT recoveries of hatchery fish at TMFD. From 1993-2004, out-of-DPS spawners have comprised from 1.8-9.7% (mean = 4.8%) of the fish that arrived at TMFD. These strays are not selectively removed because they are not distinguishable from Umatilla Hatchery supplementation steelhead. Given the length of time of influence and the hatchery fraction, we have rated the Umatilla River population at **moderate risk** for out-of-DPS spawners. This risk rating assumes that strays were present at a similar rate for the past three generations and that the proportion observed at TMFD represents proportions on the spawning grounds.

(2) *Out-of-MPG spawners from within the DPS:* There have been few, if any, out-of-MPG within-DPS spawners recovered in the Umatilla River basin, thus the rating is **very low risk** for this metric.

(3) *Out-of-population spawners from within the MPG:* There are two out-of-population within-MPG hatchery programs which could provide stray fish to the Umatilla River: Lyons Ferry Fish Hatchery releases in the Walla Walla River and Touchet River hatchery fish. No strays from these two programs have been observed. The rating is **very low risk** for this metric.

(4) *Within-population hatchery spawners:* The Umatilla River population is supplemented annually with hatchery fish produced from natural-origin broodstock collected at TMFD. The supplementation program has been ongoing since the late 1980s. Since 1993, Umatilla Hatchery fish have comprised an average of 29.4% of the naturally spawning fish. We characterize this program as using "best management practices" based on the following:

- Most of the broodstock collected annually are natural-origin fish.
- Mating protocols provide for a high number of family groups annually.
- There presently is no culling or grading of parr or smolts.
- Hatchery smolts are released in localized areas of the middle and upper mainstem.
- There does not appear to be any genetic differentiation between hatchery and natural-origin fish.

Given that best practices are used, the average hatchery fraction is 29%, and the program has been underway for three generations, the rating is **moderate risk** for within-population hatchery fish.

The spawner composition rating is **high risk** due to the moderate risk ratings for both the out-of-DPS spawners and the within-population hatchery proportions.

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution encompasses seven ecoregions, four of which account for at least 10% of the distribution (Figure 7, Table 3). There has been only one significant shift greater than 67% in the ecoregion distribution (Pleistocene Lake Basins). This population rates at **low risk**.

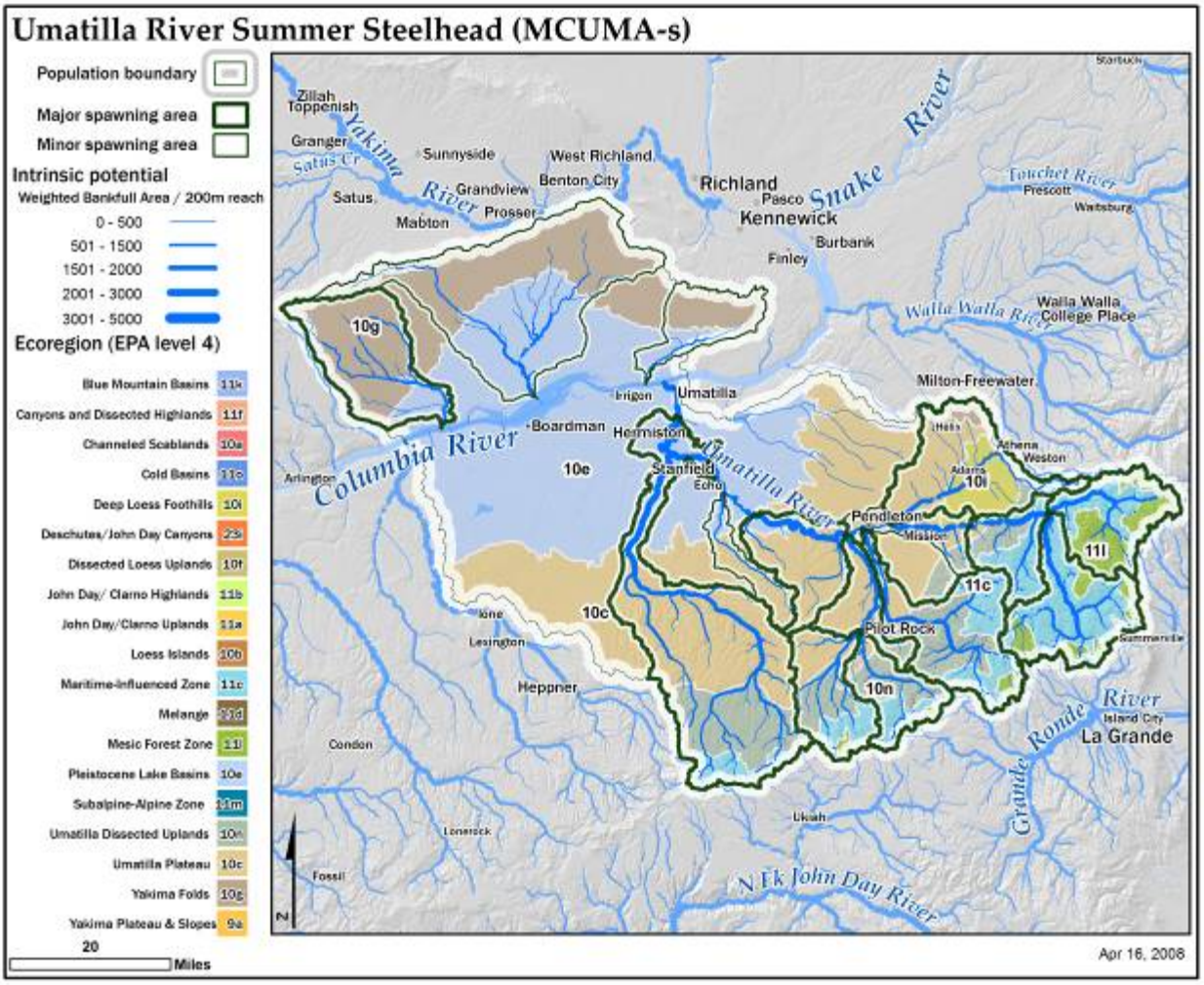


Figure 7. Umatilla River steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Umatilla River steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Umatilla Plateau	32.4	27.0
Pleistocene Lake Basins	25.0	6.2
Yakima Folds	5.3	0.0
Deep Loess Foothills	2.7	1.2
Umatilla Dissected Uplands	15.3	19.3
Maritime-influenced Zone	17.7	42.9
Mesic Forest Zone	1.7	3.4

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes three dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Juvenile migration timing:* Changes in flow and temperature patterns likely inhibit out-migration in late spring as temperatures rise and flow decreases, causing increased travel time, increased energy expenditure and greater physiological stresses. Given the number of dams that this population must cross, and likely increased mortality as the season progresses, overall selection intensity on the population is likely moderate. Heritability of this trait has not been assessed so we assume a moderate to low heritability. Therefore the impact of the hydrosystem on this trait is **moderate**.
>
> *Adult migration timing:* Umatilla River adult migrants are affected by thermal blocks that are larger in size and longer in duration relative to historic conditions in the Columbia River system. These result in delays, likely result in increased energy expenditure (due to increased temperatures) and may result in increased straying. Adult migration timing is highly heritable. The proportion of fish in the population affected is relatively unknown, although the effect likely results in low mortality. The effect is highly variable from year to year and in some years no thermal barriers develop. We rated the selection intensity as low. Thus, the impact of the hydrosystem on this trait is **moderate.**

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect only slightly more than 2% of the total population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the impacts are slight enough to be negligible. There is very limited tribal harvest of natural-origin fish within the Umatilla River subbasin and impacts from the recreational fishery are incidental to hatchery fish harvest. No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: Hatchery broodstock collection has the potential to disproportionately remove specific fish (e.g., of a certain size or timing) from the wild population. The Umatilla River summer steelhead hatchery program is operated to provide hatchery fish for harvest and to supplement natural production. Broodstock are collected at TMFD. Typically, 100 natural-origin and 20 hatchery-origin fish are collected for broodstock. Broodstock are collected representatively so that their run-timing, sex, and age of broodstock mimic that of the total run at TMFD. We are uncertain of the degree of substructure within the basin or if there are different characteristics between spawning aggregates in the basin. If life history characteristics differ between different aggregates, there is the possibility that collection of broodstock representing TMFD timing may be differentially impacting spawning aggregates. However, the broodstock removal does not appear to be selective at the population level and no phenotypic traits appear to be at risk as a result of this activity. The hatchery rating is **low risk** for all traits.

Habitat: Altered flow profiles and increased temperatures, which have been in place for many generations and are ongoing, likely impose some selection on juvenile and adult migration timing.

> *Juvenile migration timing:* Late spring and early summer temperatures are substantially elevated relative to historical conditions. There has likely been some impact on juvenile migration timing as temperatures reach stressful levels early in the summer, essentially truncating migration timing. Heritability of this trait is moderate to low and the selection intensity is assumed to be low, thus the habitat rating for this trait is **low**.
>
> *Adult migration timing:* Late summer and early fall flows are often low in the Umatilla River and likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable but a relatively low proportion of the population is likely subject to these effects, and we rated the selection intensity as moderate. Thus, the impact of habitat changes on this trait is **moderate.**

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

> *Juvenile migration timing.* Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

The adult migration timing trait has two moderate ratings and the juvenile migration timing trait has one moderate rating. Therefore, the overall selectivity rating for the Umatilla River steelhead population is **moderate risk**.

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating is **Moderate Risk** (Table 4) for the Umatilla River summer steelhead population. The rating for Goal A (allowing natural rates and levels of spatially mediated processes) was **moderate risk**. There has been significant reduction in spawner distribution relative to intrinsic potential distribution. This reduction has caused significant increases in gaps between spawning areas as well as disrupted continuity.

The rating for Goal B (maintaining natural levels of variation) was **moderate risk**. Habitat changes have been significant in the Umatilla River basin resulting in changes to flow profiles and elevated temperatures. These changes have resulted in impacts to life history diversity and phenotypic trait variation. The out-of-DPS spawners in combination with local origin hatchery fish spawning naturally put the population at high risk for spawner composition. Hydrosystem effects and within-basin habitat changes have likely resulted in selective mortality of the adult run timing phenotypic trait, resulting in a moderate risk rating for the selectivity metric.

Table 4. Umatilla River summer steelhead population spatial structure and diversity risk rating summary.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Moderate Risk
(Mean = 0.33)</td><td rowspan="3">Moderate Risk
(Mean = 0.33)</td><td rowspan="15">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>A.1.c</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.a</td><td>M (0)</td><td>M (0)</td><td rowspan="3">Moderate Risk (0)</td><td rowspan="10">Moderate Risk (0)</td></tr>
<tr><td>B.1.b</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>M (0)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk (-1)</td></tr>
<tr><td>B.2.a(2)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(4)</td><td>M (0)</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>M (0)</td><td>M (0)</td><td>M (0)</td></tr>
</table>

Overall Viability Rating

The Umatilla River summer steelhead population does not meet viability criteria. However, the population does meet criteria to be rated as **MAINTAINED** (Figure 8). Overall abundance and productivity is rated at **Moderate Risk.** The 10-year geometric mean abundance of natural-origin spawners is 1,472, which is 98.1% of the minimum abundance threshold of 1,500. The 20-year geometric mean productivity is 1.50 R/S with the lower end of the adjusted standard error above the 25% risk level. This productivity exceeds the minimum intrinsic productivity criteria of 1.26 R/S, thus placing the productivity at low risk. Overall spatial structure and diversity is also rated at **Moderate Risk.** Improvement in many of the spatial structure/diversity metrics and a small increase in the average abundance will raise the population to viable status.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M** **Umatilla River**	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 8. Umatilla River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells - does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Umatilla River Summer Steelhead Population

Data type: Estimated number of annual spawners estimated based on annual counts at Three Mile Falls Dam in the lower Umatilla River. Natural-origin proportion estimated based on hatchery and natural-origin counts, adjusted for removals or mortalities above the dam.

SAR: Mid-Columbia SAR index (incorporates the Deschutes, Umatilla, Snake, and Upper Columbia River steelhead series).

Table 5. Umatilla River steelhead population abundance and productivity data used for curve fits and R/S analysis. Bold values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1981	**1,115**	**1.00**	**1,115**	**2,635**	**2.36**	**0.68**	**1799**	**1.61**
1982	**609**	**1.00**	**609**	**2,640**	**4.33**	**0.46**	**1207**	**1.98**
1983	**974**	**1.00**	**974**	**2,525**	**2.59**	**0.52**	**1322**	**1.36**
1984	1,998	1.00	1,998	1,943	0.97	0.65	1257	0.63
1985	2,732	1.00	2,732	1,559	0.57	0.46	716	0.26
1986	2,487	1.00	2,487	1,017	0.41	0.94	959	0.39
1987	2,911	1.00	2,911	1,144	0.39	2.18	2490	0.86
1988	2,201	0.93	2,050	1,573	0.71	0.99	1558	0.71
1989	2,179	0.84	1,841	1,105	0.51	0.96	1062	0.49
1990	1,301	0.96	1,247	873	0.67	2.83	2471	1.90
1991	**700**	**0.85**	**592**	**593**	**0.85**	**2.33**	**1384**	**1.98**
1992	2,118	0.90	1,915	1,380	0.65	1.88	2594	1.22
1993	1,572	0.74	1,165	713	0.45	1.18	842	0.54
1994	**1,074**	**0.79**	**847**	**885**	**0.82**	**1.07**	**948**	**0.88**
1995	1,298	0.60	783	1,154	0.89	1.23	1414	1.09
1996	1,811	0.66	1,194	2,975	1.64	1.03	3070	1.70
1997	2,215	0.41	914	2,210	1.00	0.76	1687	0.76
1998	1,529	0.50	771	3,836	2.51	0.49	1880	1.23
1999	1,595	0.64	1,020	1,071	0.67	0.52	554	0.35
2000	2,621	0.77	2,030	2,584	0.99	1.00	2584	0.99
2001	3,353	0.73	2,444					
2002	5,172	0.68	3,542					
2003	2,822	0.71	2,015					
2004	3,109	0.64	2,003					

Table 6. Umatilla River steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		Nat. origin
delimited	median	75% threshold	median	75% threshold	1989-2000	1981-2000	geomean
Point Est.	1.24	1.79	1.14	1.50	1.07	1.06	1472
Std. Err.	0.24	0.33	0.19	0.15	0.02	0.06	0.22
count	10	5	10	5	12	20	10

Table 7. Umatilla River steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey (included for comparison only - not used in the assessment of current abundance/productivity).

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	0.94	0.14	n/a	n/a	0.27	0.60	44.5	0.89	0.12	n/a	n/a	0.31	0.31	40.3
Const. Rec	1512	174	n/a	n/a	n/a	n/a	34.8	1438	147	n/a	n/a	n/a	n/a	30.2
Bev-Holt	22.07	116.06	1587	446	0.21	0.44	37.5	8.48	15.93	1625	425	0.20	-0.15	32.7
Hock-Stk	1.92	0.70	806	310	0.21	0.45	38.1	1.98	0.64	735	249	0.20	-0.18	32.8
Ricker	2.70	0.88	0.00060	0.00017	0.22	0.45	38.0	2.35	0.69	0.00055	0.00016	0.21	-0.14	33.4

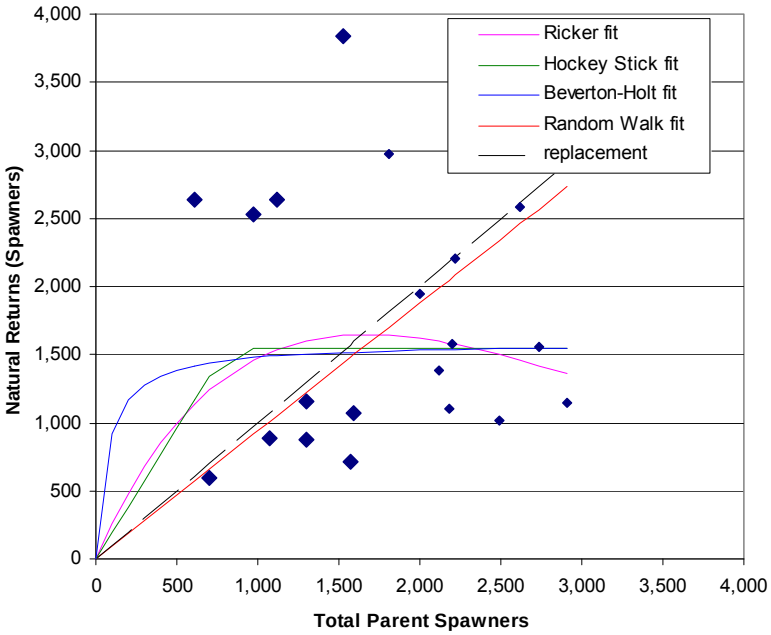


Figure 9. Umatilla River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

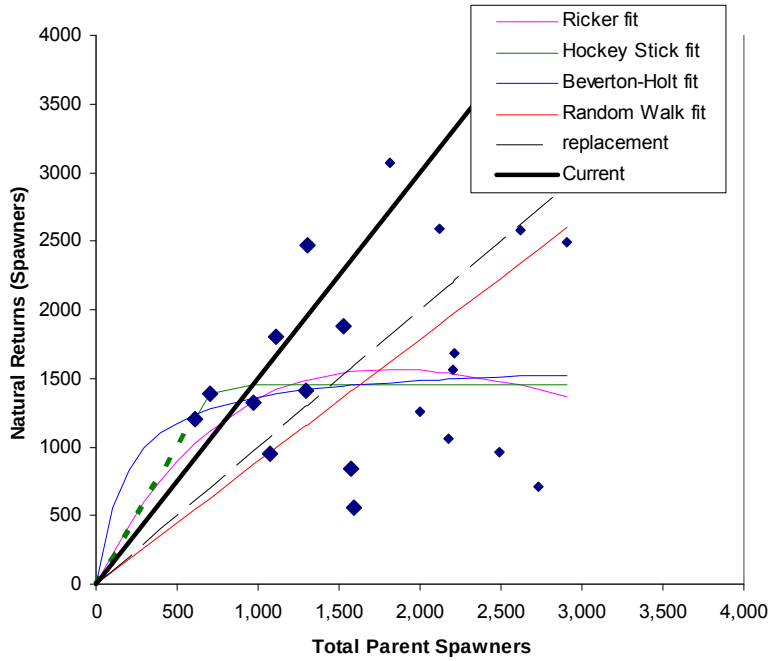


Figure 10. Umatilla River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "Current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

Walla Walla River Summer Steelhead Population

The Walla Walla River summer steelhead population (Figure 1) is one of three populations in the Umatilla/Walla Walla Rivers MPG within the Mid-Columbia River DPS. All three populations in this MPG are summer run.

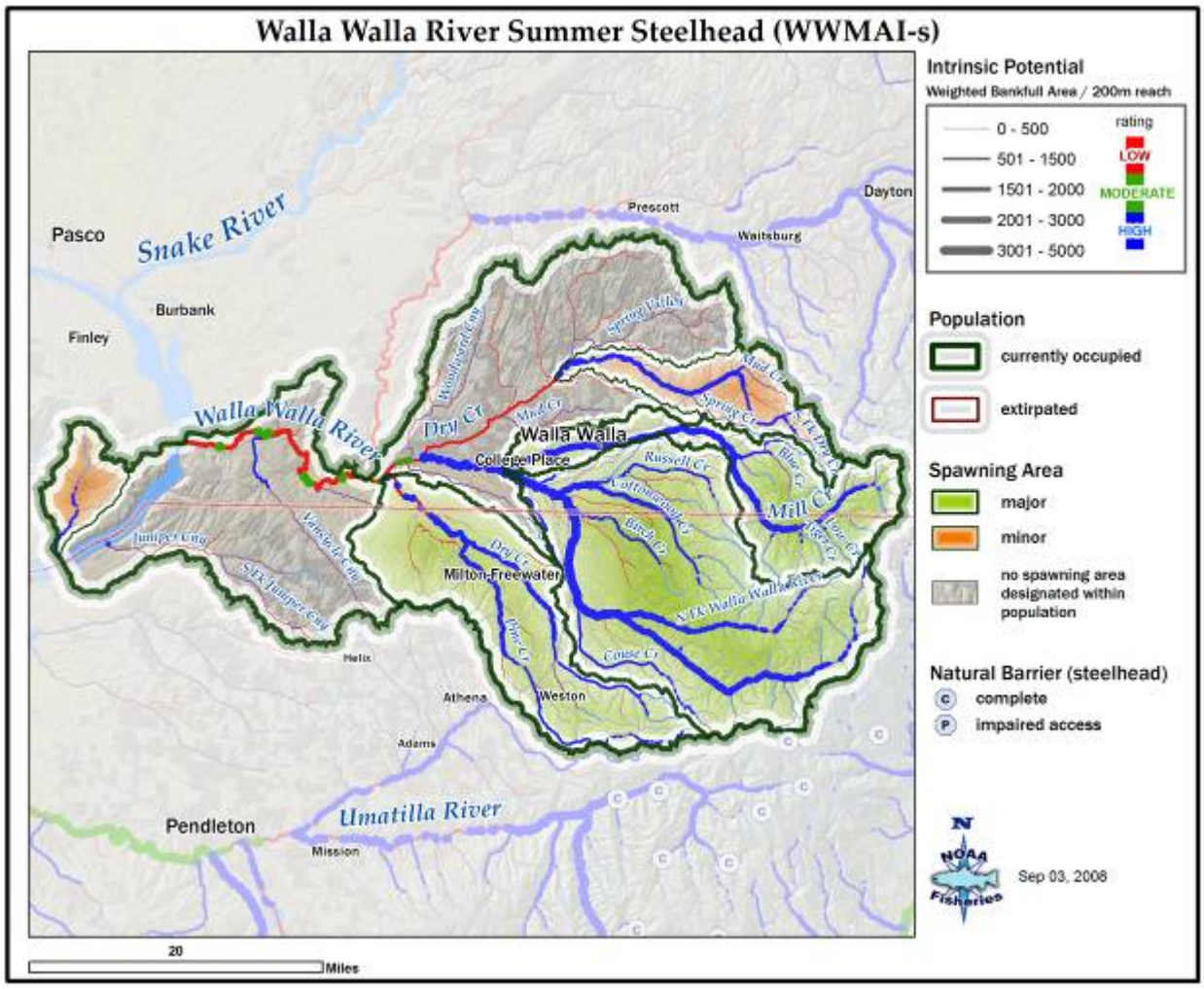


Figure 1. Walla Walla River summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas.

The Interior Columbia Technical Recovery Team (ICTRT) classified the Walla Walla River population as "intermediate" in size and complexity based on historical habitat potential (Table 1). A steelhead population classified as intermediate has a mean minimum abundance threshold of 1,000 natural-origin spawners with sufficient intrinsic productivity (≥ 1.35 recruits per spawner at the minimum abundance threshold) to achieve a 5% or less risk ("low risk") of extinction over a 100-year timeframe. In order for the Walla Walla River population to achieve a 1% or less risk ("very low risk") of extinction over 100 years, productivity would need to be at or greater than 1.64 recruits per spawner at the minimum abundance threshold.

Table 1. Walla Walla River summer steelhead population basin statistics and intrinsic potential analysis summary.

Drainage area (km^2)	2,988
Stream lengths km (total) [a]	1,147
Stream lengths km (below natural barriers) [a]	1,111
Branched stream area weighted by intrinsic potential (km^2)	2.448
Branched stream area km^2 (weighted and temp. limited) [b]	0.774
Total stream area weighted by intrinsic potential (km^2)	3.711
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	0.907
Size / Complexity category	Intermediate / "B" (dendritic)
Number of major spawning areas (MaSAs)	3
Number of minor spawning areas (MiSAs)	2

a. All stream segments ≥ 3.8m bankfull width were included.
b. Temperature limited areas were assessed by subtracting area where mean weekly modeled water temperature was > 22°C.

Current Abundance and Productivity

Current (1993 to 2003) total spawner abundance (number of adult spawners in natural production areas) has ranged from 421 in 1999 to 1,811 in 2002 (Figure 2). Abundance of natural-origin summer steelhead in the portion of the Walla Walla River basin above Nursery Bridge Dam (NBD; North Fork, South Fork, and Couse Creek) was determined from counts of adult returns to NBD at river mile 44. These counts did not include removals or mortality at and above the dam. Fish were enumerated using trap counts and mark-recapture methods from brood years (BY) 1993-2001, and video counts in BY 2002, 2003, and 2005. Mark-recapture methods were used to account for fish that jumped the dam. Mark-recapture methods were discontinued following dam modifications that are thought to prevent fish from jumping the dam (T. Bailey, Oregon Department of Fish & Wildlife, personal communication). Almost all hatchery fish trapped at NBD were removed during BY 1993-1999. The BY 2003 count (547) was incomplete as the west side ladder was opened from February 21 through March 11 due to passage problems with the east side ladder. Fish passing through the west bank ladder were not counted. The number of uncounted fish in BY 2003 was estimated as the mean percent of the run that passed NBD from February 21-March 11 during BY 1993-2001 (12.3%). The percent of the run passing NBD during that time period ranged from 5.4 % to 18.7% during BY 1993-2001. Counts were not available for BY 2004 because video equipment was inoperable during most of the migration season. Missing abundance data for BY 2004 were reconstructed using mean brood age structure estimated from BY 1991-1998 data and all available counts of brood returns in years before and after the 2004 missing count. Age structure was determined by scale analyses from adults returning in 1993-1995. Missing run year age structure data after 1995 were estimated as the 1993-1995 mean age structure. Origin (natural or hatchery) could not be determined from video monitoring (2002-2005) and was estimated as the 1993-2001 mean percent of natural (96.4%) and hatchery (3.6%) origin fish in the run to NBD. Spawner abundance for the entire Walla Walla River natural-origin summer steelhead population was estimated by expanding abundance of spawners above NBD by a factor of 1.503. The expansion estimate was developed from the ratio of current smolt capacity of the entire population divided by the current smolt capacity above NBD. The current smolt capacity estimates were developed based on Ecosystem-Diagnosis-Treatment (EDT) analyses of current conditions. Harvest removals were not factored into the estimate of spawning escapement above NBD. Tribal and non-tribal fishing pressure is thought to be minimal (T. Bailey, personal communication).

Recreational angling was prohibited from 1996-2002 and limited to retention of hatchery-origin fish after 2002.

Recent natural spawners include returns originating from naturally spawning adults and from outside-DPS spawners that originate from Lyons Ferry Hatchery releases in the lower Walla Walla River. Natural-origin fish have comprised an average of 98% over the 11 years of available data. Throughout the period, the percentage of natural-origin fish has ranged from 95.4% to 99.8%.

Abundance in recent years has been moderately variable. The 10-year (1996-2005) geometric mean abundance of natural-origin spawners was 650 (Table 3.3.2-2). During the period 1993-2000, recruits per spawner (R/S, in terms of spawner to spawner) for steelhead in the Walla Walla River ranged from 0.39 in 1993 to 2.65 in 1998. The annual R/S estimates were adjusted to reflect the average smolt-to-adult return rate (SAR). The 8-year (1993-2000) geometric mean productivity was 1.34 R/S, adjusted for SAR and delimited at 75% (750 spawners) of the abundance threshold (Table 2).

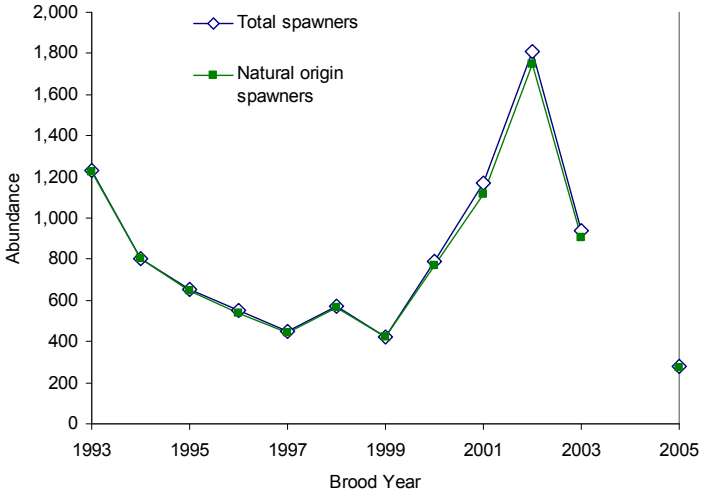


Figure 2. Walla Walla River summer steelhead population spawner abundance estimates (1993-2005).

Table 2. Walla Walla River summer steelhead population abundance and productivity estimates.

Abundance/Productivity Statistics	Estimate	(Range)	
Abundance: natural-origin spawners (10-year geometric mean, range)	650	(270-1746)	
Proportion: natural-origin spawners (10-year geometric mean, range)	0.98	(0.95-1.00)	
	Estimate	**(90% CI)[b]**	**SE**
Intrinsic productivity (8-year R/S, SAR adjusted & delimited) [a]	1.34	(1.05-1.71)	0.12
Productivity (8-year Beverton-Holt fit, SAR adjusted)	n/a		n/a
Trend Statistics (1980-2005) [c]	**Estimate**	**(95% CI)**	**P>1.0**
ln(natural-origin spawner abundance)	n/a		
Population growth rate (λ): Hatchery effectiveness = **1.0**	n/a		
Population growth rate (λ): Hatchery effectiveness = **0.0**	n/a		

a. Delimited productivity excludes any recruit/spawner pair where the spawner number >75% of the population's minimum abundance threshold. This approach attempts to remove density dependence effects that may influence the productivity estimate.
b. Lower end of the 90% CI on productivity is used in evaluating the impact of parameter uncertainty on risk.
c. Insufficient data series to calculate 1980- 2005 trend metrics.

The Walla Walla River summer steelhead population is at M**oderate Risk** based on current abundance and productivity. The point estimate falls between the 5% and 25% risk curves (Figure 3). The moderate risk rating should be viewed with caution given two considerations: 1) the time series is short, with only eight brood years, and there is considerable uncertainty if the data adequately represent the true value; and 2) there is considerable uncertainty associated with the amount of spawning and production that occurs within the

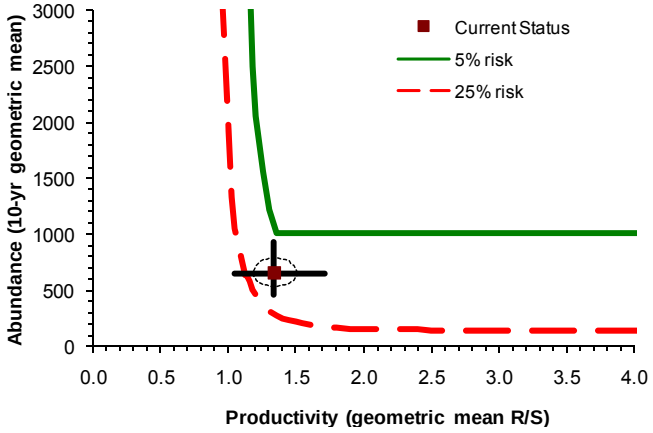


Figure 3. Walla Walla River summer steelhead population current abundance/productivity (A/P) compared to the DPS viability curve. Ellipse = 1 SE about the point estimate. Error bars = 90% CI for A/P.

population outside of the area above Nursery Bridge Dam, particularly in Mill Creek. Better information relating abundance above Nursery Bridge Dam to the remaining area in the population is needed to reduce this data uncertainty.

The natural-origin spawner abundance series for the Walla Walla steelhead population was initiated in 1993; therefore it was not possible to calculate the 1980-present trend metrics. The general pattern over the 1993 to 2005 period is similar to the patterns in returns over the same period for other Mid-Columbia DPS steelhead populations: declining annual abundance followed by a short increasing trend beginning in 1999 and then an abrupt decline after 2003.

Spatial Structure and Diversity

The ICTRT has identified three historic major spawning areas (MaSAs) and two minor spawning areas (MiSAs) within the Walla Walla River steelhead population (Figure 4). Two small watersheds, which are classified as MiSAs and which empty directly into the Columbia River below the Walla Walla River confluence, are included in the Walla Walla population boundaries (Juniper Canyon, OR and Switzler, WA). Current spawning distribution is substantially reduced relative to the historic intrinsic distribution. Current production is concentrated in the North and South Fork Walla Walla River, Couse Creek, Mill Creek and Dry Creek (WA). It should be noted that the map does not show Yellowhawk Creek, which runs between Mill Creek and Cottonwood Creek, and there is spawning in the lower reaches of Yellowhawk Creek. Spawners within the Walla Walla population are primarily natural-origin fish with a small proportion of hatchery strays which are Snake River-origin fish produced at Lyons Ferry Hatchery and released into the lower Walla Walla River. Hatchery fish were removed at NBD by trapping until 1999 when it was discontinued and replaced with video monitoring. Currently, hatchery fish pass above NBD to spawn naturally.

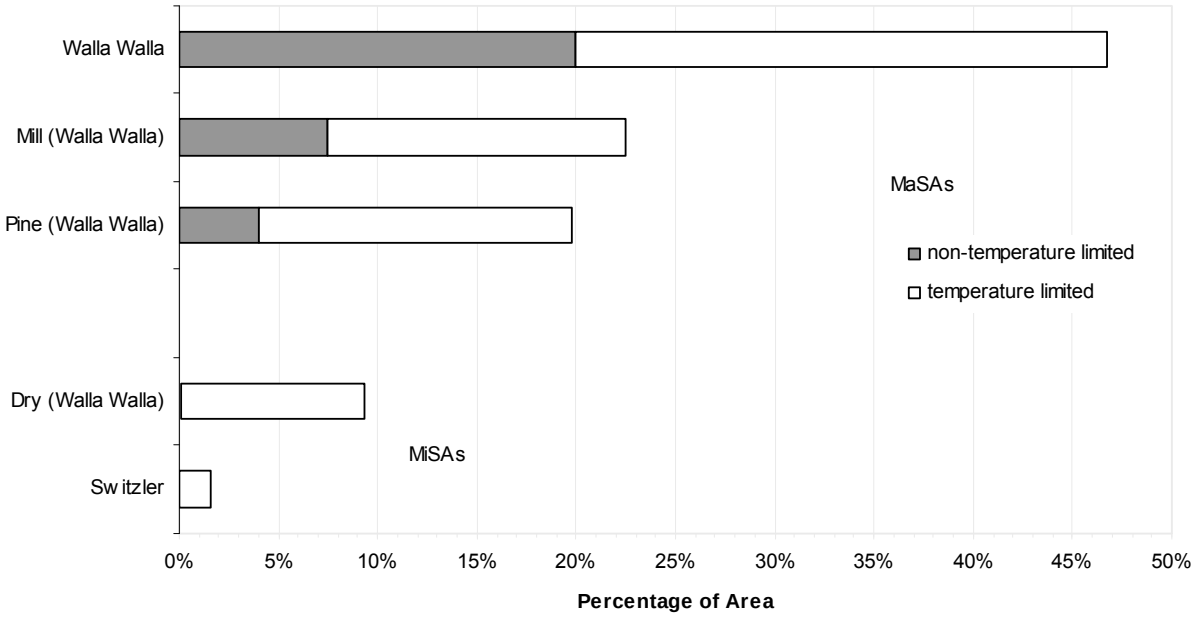


Figure 4. Walla Walla River summer steelhead population distribution of intrinsic potential habitat across major and minor spawning areas. White bars represent current temperature limited areas that could potentially have had historical temperature limitations.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas

The Walla Walla River population has three MaSAs and two MiSAs distributed in a dendritic pattern. Historically, major production areas included Pine Creek, South Fork Walla Walla River, North Fork Walla Walla River, Mill Creek, Cottonwood Creek and Dry Creek (WA). Spawning distribution has been reduced significantly relative to historic distribution. Currently two of three of the MaSAs are occupied, including Walla Walla and Mill. Spawning and rearing do not occur in the Pine Creek MaSA. One of two MiSAs is occupied—Dry Creek. Even though there has been significant reduction in distribution, the population rated at **low risk** because it has two MaSAs occupied in a dendritic pattern.

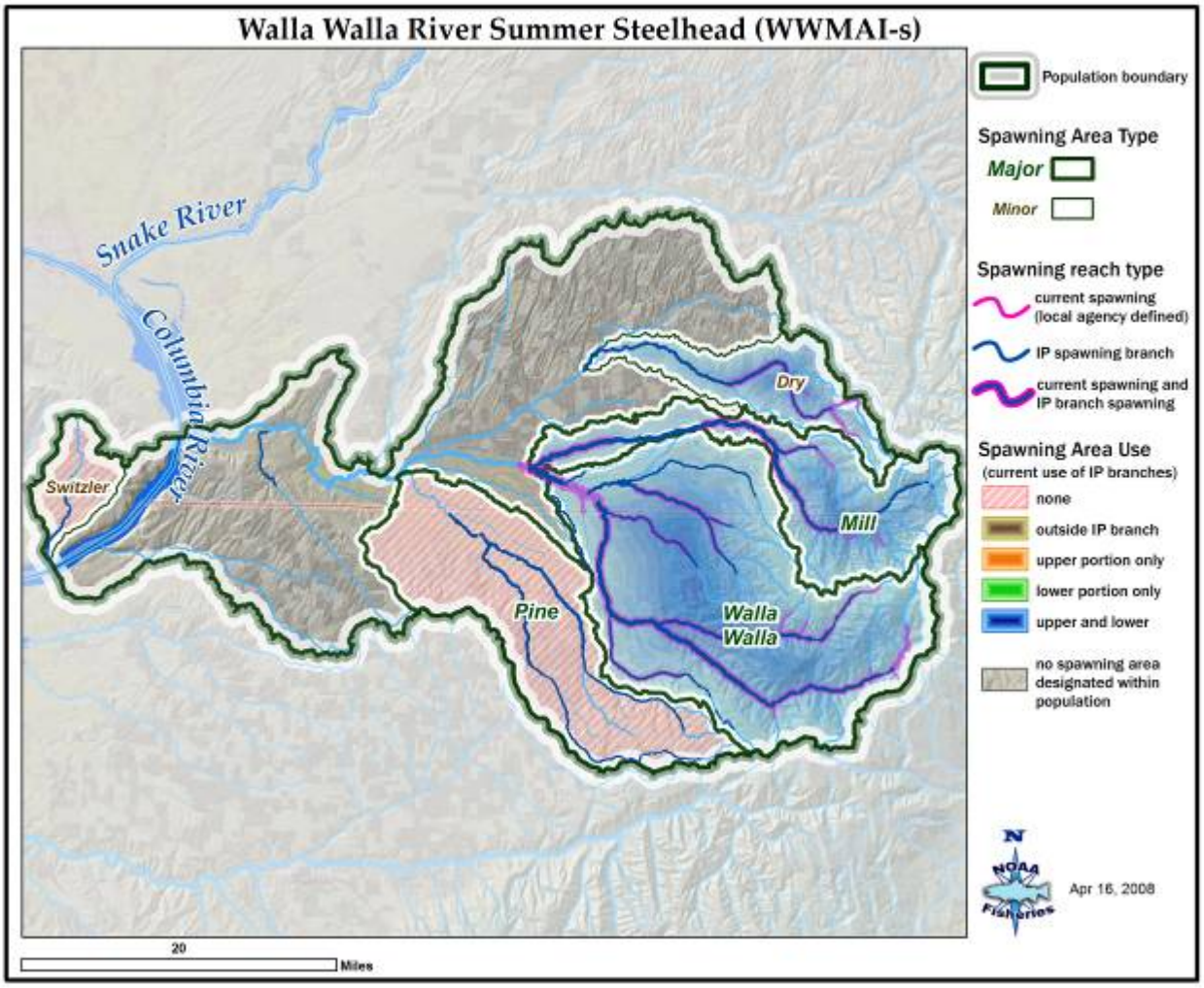


Figure 5. Walla Walla River summer steelhead population current spawning distribution and spawning area occupancy designations.

A.l.b. Spatial extent or range of population

Based on comparisons of the current spawner distribution databases from the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW) with the intrinsic distribution, there has been substantial reduction in the range. Currently two of three MaSAs (67%) and one of two MiSAs (50%) are occupied (Figure 5). Due to the significant reduction, the population is rated at **moderate risk** because less than 75% (but greater than 50%) of the historical MaSAs are currently occupied. . There are limited spawning survey data to evaluate occupancy for this population. Additional spawning survey data needs to be collected to improve future viability assessments.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates

There have been significant changes in gaps and continuity as a result of the loss of spawning in the Pine Creek MaSA and the Switzler MiSA. The loss of occupancy in these areas has increased the distance between the Walla Walla population and other Mid-Columbia DPS steelhead populations. Due to these considerations, and because less than 75% of the historical MaSAs are occupied, the population is rated at **moderate risk** for this metric.

B.1.a. Major life history strategies

We have no data to allow any direct comparisons between historic and current life history strategies. Flow and temperature changes and barriers in the Walla Walla River basin have limited movement patterns of juvenile and adult steelhead during recent decades. Juvenile steelhead are unable to use many of the mainstem areas during the summer months due to high temperatures and low flows. Adults are unable, in some years, to enter the Walla Walla River in early fall. These types of changes have likely resulted in reduced life history diversity. However, it does not appear that any major life history pathways have been lost. The age structure and run-timing of adults is within the range observed for other summer steelhead populations. The population exhibits multiple ages of smolt out-migration and ocean residence time, as well as repeat spawners. The habitat changes have likely resulted in significant reduction in variability as well as a change in distribution of life history pathways, thus we have rated the population at **moderate risk** for this metric.

B.1.b. Phenotypic variation

There are no data to assess loss or substantial change in phenotypic traits, therefore we infer from habitat changes. The changes in flow patterns and temperature profile within the Walla Walla River, as well as the effects of adult passage barriers, have likely resulted in reduced adult and juvenile phenotypic traits. Juveniles have narrower windows for successful out-migration through the Walla Walla River as well as through the Columbia River. Adults cannot enter and migrate through the Walla Walla River during late summer and early fall in some years due to temperature limitations. The Walla Walla population rated at **moderate risk** because of likely change in mean and variability of two or more phenotypic traits.

B.1.c. Genetic variation

The genetic information for the Walla Walla population demonstrates levels of within and between-population differentiation that are healthy and do not indicate any substantial change from likely historical condition. In addition, there is little signal of introgression of outside-DPS hatchery fish which are known to be present in spawning areas. The population rated at **low risk** for genetic variation.

B.2.a. Spawner composition

(1) *Out-of-DPS spawners*: There are out-of-DPS spawners present in the population that originate from Lyons Ferry hatchery releases into the mainstem Walla Walla River. Until 1999, wandering hatchery fish destined for the upper Walla Walla River basin were removed at Nursery Bridge Dam. Since that time, hatchery fish have passed upstream to spawn naturally. The removal of these out-of-basin hatchery-origin fish had reduced the hatchery proportion and the risk to the natural population. We estimated that about 2% of the natural spawners have been out-of-basin hatchery-origin fish for recent generations. With 2% out-of-DPS spawners for the past three generations the population is rated at **moderate risk**. It should be noted that two management actions may influence the future proportion of the out-of-DPS spawners. Annual smolt releases from Lyons Ferry Hatchery have been reduced substantially which will reduce the source of hatchery adults. On the other hand, hatchery fish are no longer removed at Nursery Bridge Dam which results in an increase in the proportion of hatchery spawners above this location. The overall effect of these two offsetting management changes is unknown.

(2) *Out-of-MPG spawners from within the DPS*: There are no documented out-of-MPG within-DPS strays in this population, so the rating is **very low risk** for this metric.

(3) *Out-of-population spawners within the MPG*: There are no documented out-of-population within-MPG strays, so the rating is **very low risk** for this metric. However, this risk rating may increase in the future due to potential within-population Touchet River hatchery strays.

(4) *Within-population hatchery spawners*: There is no within population hatchery program, so the population is rated at **very low risk** for this metric.

The overall spawner composition rating is **moderate risk** due to the moderate risk of out-of-DPS hatchery strays spawning naturally in this population.

B.3.a. Distribution of population across habitat types

The intrinsic potential distribution of the Walla Walla River population encompassed six ecoregions, of which four accounted for 10% or more of the ecoregion distribution (Figure 6, Table 3). Within these four ecoregions there have been no significant changes in the proportions from the historic intrinsic to the current distribution. The population is rated at **very low risk** because all historical ecoregions are occupied, there are more than four currently occupied, and there have been no substantial changes in ecoregion occupancy (Table 3).

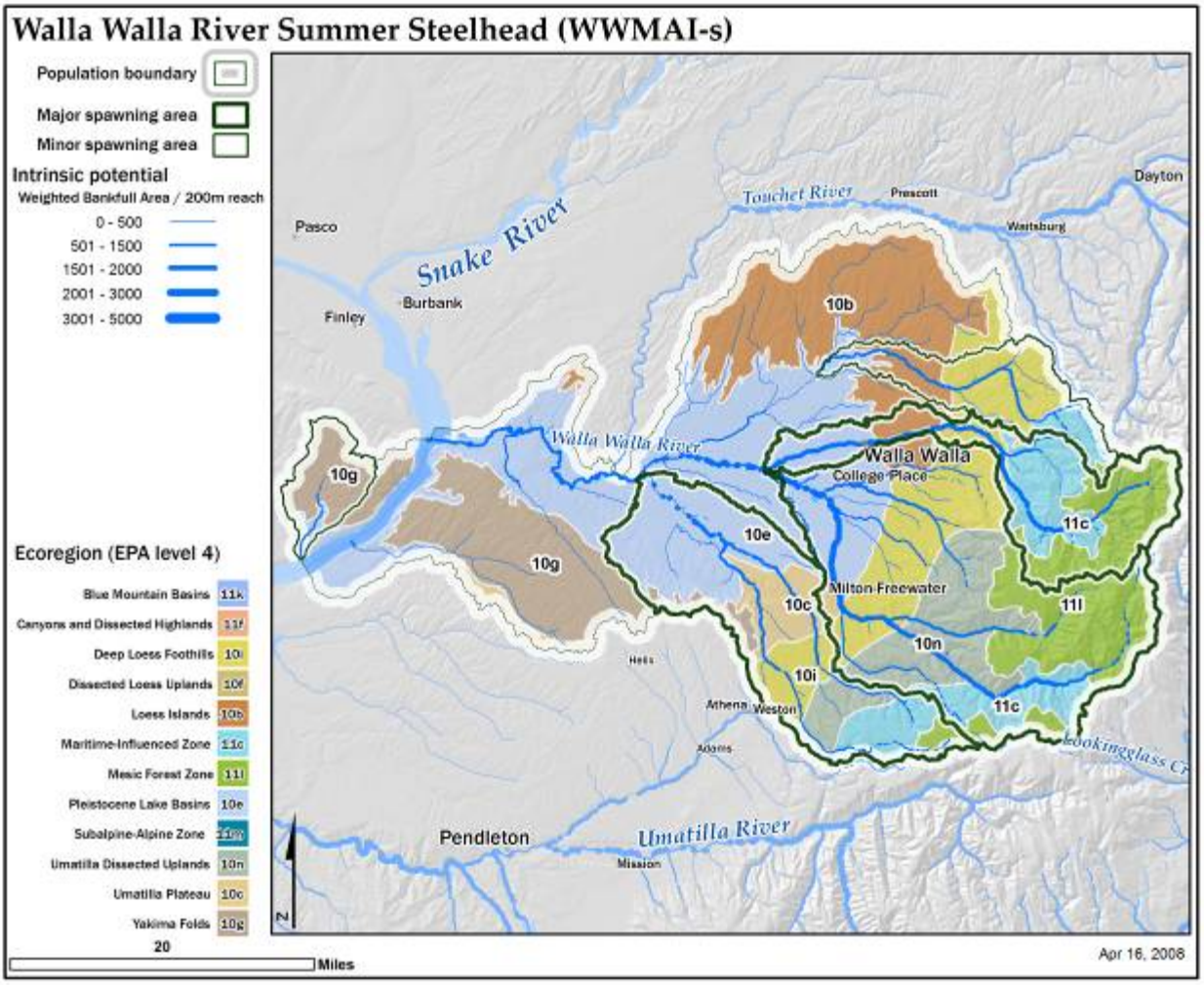


Figure 6. Walla Walla River summer steelhead population spawning distribution across EPA level IV ecoregions.

Table 3. Walla Walla River summer steelhead population proportion of current spawning areas across EPA level IV ecoregions.

Ecoregion	% of historical spawning area (non-temp. limited)	% of currently occupied spawning area (non-temp. limited)
Deep Loess Foothills	19.0	30.4
Loess Islands	8.0	0.9
Maritime-Influenced Zone	11.1	18.8
Mesic Forest Zone	4.6	6.6
Pleistocene Lake Basins	45.9	25.8
Umatilla Dissected Uplands	11.3	17.6

B.4.a. Selective change in natural processes or selective impacts

Hydropower system: This population passes four dams on the lower mainstem Columbia River in its seaward and spawning migrations. The hydropower system and associated reservoirs appear to impose some selection on smolt and adult migration timing. All hydropower effects have persisted for multiple generations and are ongoing.

> *Juvenile migration timing:* Changes in flow and temperature patterns likely inhibit out-migration in late spring as temperatures rise and flow decreases, causing increased travel time, energy expenditure and physiological stress. Given the number of dams that this population must cross, and likely increased mortality as the season progresses, overall selection intensity on the population is likely moderate. Heritability of this trait has not been assessed so we assume a moderate to low heritability. Therefore the impact of the hydrosystem on this trait is **moderate**.
>
> *Adult migration timing:* Adult migrants are affected by thermal blocks that are larger in size and longer in duration relative to historic conditions in the Columbia River system. These result in delays, likely result in increased energy expenditure (due to increased temperatures) and may result in increased straying. Adult migration timing is highly heritable. The proportion of fish in the population affected is relatively unknown, although the effect likely results in low mortality. The effect is highly variable from year to year and in some years no thermal barriers develop. We rated the selection intensity as low. Thus, the impact of the hydrosystem on this trait is **moderate.**

Harvest: Harvest has the potential to affect migration timing, maturation timing and size. However, recent harvest rates for A-run steelhead in the Columbia River mainstem are generally less than 10% annually. Although some harvest may be size-selective for larger fish, the selective mortality would affect slightly greater than 2% of the largest fish in the population. There may be a very slight advantage for earlier returning fish as a result of the timing of the Chinook salmon fishery, and while heritability of adult migration timing is high, the selection intensity is low enough to be negligible. There is very limited tribal harvest of natural-origin fish within the Walla Walla River subbasin and impacts from the recreational fishery are incidental to hatchery fish harvest No phenotypic traits appear to be at risk as a result of this activity. The harvest rating is **low risk** for all traits.

Hatcheries: No natural-origin adults are collected for broodstock within the population; therefore, the hatchery rating is **low risk** for all traits.

Habitat: Altered flow profiles and increased temperatures, which have been in place for many generations and are ongoing, likely impose some selection on juvenile and adult migration timing.

> *Juvenile migration timing:* Late spring and early summer temperatures are elevated relative to historical conditions. There has likely been some effect on juvenile migration timing as temperatures reach stressful levels early in the summer. Juvenile migration timing has likely been truncated; however we are uncertain of the degree of change. Heritability of this trait is moderate to low, and the selection intensity is assumed to be low, therefore the impact of habitat changes on this trait is **low.**

Adult migration timing: Late summer and early fall flows are often low in the Walla Walla River and likely expose adults that enter the river early to above normal mortality rates. Adult migration timing is highly heritable but a relatively low proportion of the population is likely subject to these effects, and we rated the selection intensity as moderate. Thus, the impact of habitat changes on this trait is **moderate.**

Other: A population of Caspian terns in the estuary has been artificially enhanced by a combination of increased habitat (created by dredge spoils) and artificially increased food availability (large-scale releases of hatchery smolts). These terns appear to exert a size-selective predation pressure that primarily impacts the large steelhead smolts. The rate of predation is highest during tern nesting season in May. This pressure may affect smolt migration timing.

Juvenile migration timing. Steelhead smolts pass through the estuary from April to June. The relatively high predation (10%) on smolts in May could select for earlier and later out-migrants. However, heritability of this trait has not been assessed, so we assume a moderate to low heritability. Because this predation occurs at the peak of migration, the impact of this selective factor is **low risk**.

The adult migration timing trait has two moderate ratings and the juvenile migration timing trait has one moderate rating. Therefore, the overall selectivity rating for the Walla Walla River steelhead population is **moderate risk**.

Spatial Structure and Diversity Summary

The integrated spatial structure/diversity rating for the Walla Walla River summer steelhead population is **Moderate Risk** (Table 4). The rating for Goal A (allowing natural rates and levels of spatially mediated processes) was **moderate risk**. There has been significant reduction in spawner distribution which has resulted in increased gaps and loss of continuity within the population and between the Walla Walla population and other Mid-Columbia DPS steelhead populations.

The rating for Goal B (maintaining natural levels of variation) was **moderate risk**. Water temperature and hydrograph changes as well as barriers have likely influenced life history diversity and phenotypic expression. Out-of-DPS spawners have put the population in the moderate risk category for the spawner composition metric. Hydrosystem effects and within-basin habitat changes have likely resulted in selective mortality of the adult run timing phenotypic trait, resulting in a moderate risk rating for the selectivity metric.

Table 4. Walla Walla River summer steelhead population spatial structure and diversity risk rating.

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Moderate Risk
(Mean = 0.33)</td><td rowspan="3">Moderate Risk
(Mean = 0.33)</td><td rowspan="15">Moderate Risk</td></tr>
<tr><td>A.1.b</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>A.1.c</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.a</td><td>M (0)</td><td>M (0)</td><td rowspan="3">Moderate Risk (0)</td><td rowspan="10">Moderate Risk (0)</td></tr>
<tr><td>B.1.b</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.c</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.2.a(1)</td><td>M (0)</td><td rowspan="4">Moderate Risk
(0)</td><td rowspan="4">Moderate Risk (0)</td></tr>
<tr><td>B.2.a(2)</td><td>VL (2)</td></tr>
<tr><td>B.2.a(3)</td><td>VL (2))</td></tr>
<tr><td>B.2.a(4)</td><td>VL (2)</td></tr>
<tr><td>B.3.a</td><td>VL (2)</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.4.a</td><td>M (0)</td><td>M (0)</td><td>M (0)</td></tr>
</table>

Overall Viability Rating

The Walla Walla River summer steelhead population does not meet viability criteria. However, the population does meet ICTRT criteria to be rated as **MAINTAINED** (Figure 7). Overall abundance and productivity is rated at **Moderate Risk.** The 10-year geometric mean abundance of natural-origin spawners is 650, which is 65% of the minimum abundance threshold of 1,000. The 8-year geometric mean productivity (1.34 R/S; Table 6) is nearly at the 1.35 R/S minimum required at the abundance threshold. However, there is considerable uncertainty due to the short time series. Analysis of additional brood years will be critical to demonstrating sustained recruits per spawner and abundance values above the low risk criteria level. Overall spatial structure and diversity is also rated at **Moderate Risk.** Significant improvements to spatial structure and diversity are needed to improve the risk level.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M Walla Walla River**	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 7. Walla Walla River summer steelhead population risk ratings integrated across the four viable salmonid population (VSP) metrics. ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; Shaded cells – does not meet viability criteria (darkest cells are at greatest risk).***

Data Summary – Walla Walla River Summer Steelhead Population

Data type: Dataset reconstructed from dam counts
SAR: Averaged Deschutes, Umatilla, Snake, and Upper Columbia River steelhead series
Productivity: Only 8 recruit/spawner pairs for this population exist; therefore results must be interpreted carefully.

Table 5. Walla Walla River summer steelhead population abundance and productivity data used for curve fits and R/S analysis. Bold values were used in estimating the current productivity (Table 6).

Brood Year	Spawners	%Wild	Natural Run	Nat. Rtns	R/S	SAR Adj. Factor	Adj. Rtns	Adj. R/S
1993	1228	99.8%	1,225	474	0.39	1.18	561	0.46
1994	806	99.8%	804	525	0.65	1.07	562	0.70
1995	**654**	**98.8%**	**646**	**497**	**0.76**	**1.23**	**609**	**0.93**
1996	**549**	**98.0%**	**538**	**753**	**1.37**	**1.03**	**777**	**1.42**
1997	**447**	**98.2%**	**439**	**1128**	**2.52**	**0.76**	**861**	**1.93**
1998	**573**	**99.1%**	**568**	**1517**	**2.65**	**0.49**	**744**	**1.30**
1999	**421**	**99.5%**	**419**	**1082**	**2.57**	**0.52**	**560**	**1.33**
2000	792	97.5%	772	618	0.78	1.00	618	0.78
2001	1172	95.4%	1,118					
2002	1811	96.4%	1,746					
2003	938	96.5%	905					
2004								
2005	281	96.1%	270					

Table 6. Walla Walla River summer steelhead population geometric mean abundance and productivity estimates (values used for current productivity and abundance are shown in boxes).

	R/S measures				Lambda measures		Abundance
	Not adjusted		SAR adjusted		Not adjusted		
delimited	median	75% threshold	median	75% threshold	1993-2001	1980-1999	Nat. origin geomean
Point Est.	2.20	1.78	1.47	1.34	1.14	n/a	650
Std. Err.	0.16	0.25	0.09	0.12	0.01	n/a	0.19
count	4	5	4	5	9	n/a	9

Table 7. Walla Walla River summer steelhead population stock-recruitment curve fit parameter estimates. Biologically unrealistic or highly uncertain values are highlighted in grey.

	Not adjusted for SAR							Adjusted for SAR						
SR Model	a	SE	b	SE	adj. var	auto	AICc	a	SE	b	SE	adj. var	auto	AICc
Rand-Walk	1.17	0.29	n/a	n/a	0.29	0.62	23.2	1.01	0.16	n/a	n/a	0.12	0.61	15.8
Const. Rec	756	109	n/a	n/a	n/a	n/a	14.8	653	37	n/a	n/a	n/a	n/a	-0.4
Bev-Holt	50.00	104.52	773	122	0.10	0.65	20.6	50.00	81.92	667	45	0.02	0.52	5.6
Hock-Stk	1.17	0.17	19583	0	0.29	0.62	28.8	1.47	0.08	447	0	0.02	0.56	4.6
Ricker	6.54	2.15	0.00252	0.00045	0.08	0.38	16.1	3.17	0.49	0.00167	0.00021	0.02	0.22	3.9

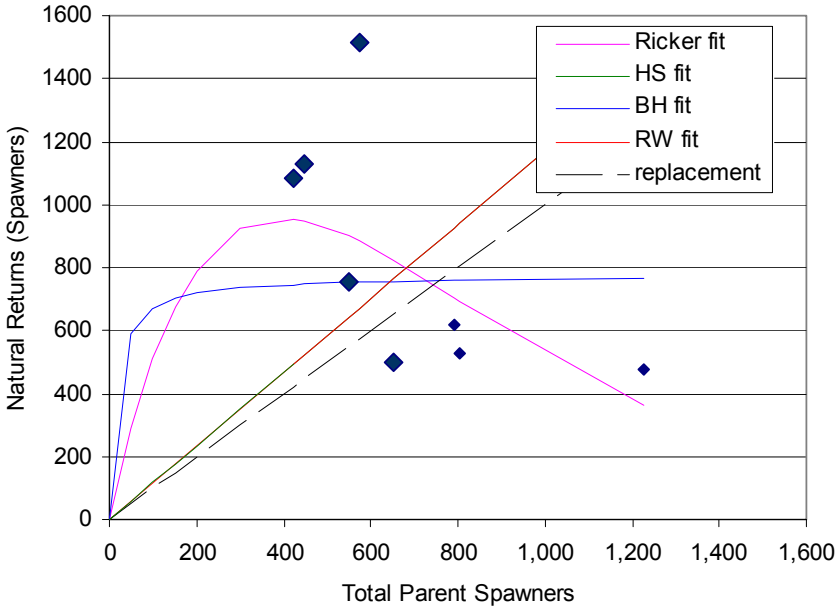


Figure 8. Walla Walla River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were not adjusted for marine survival.

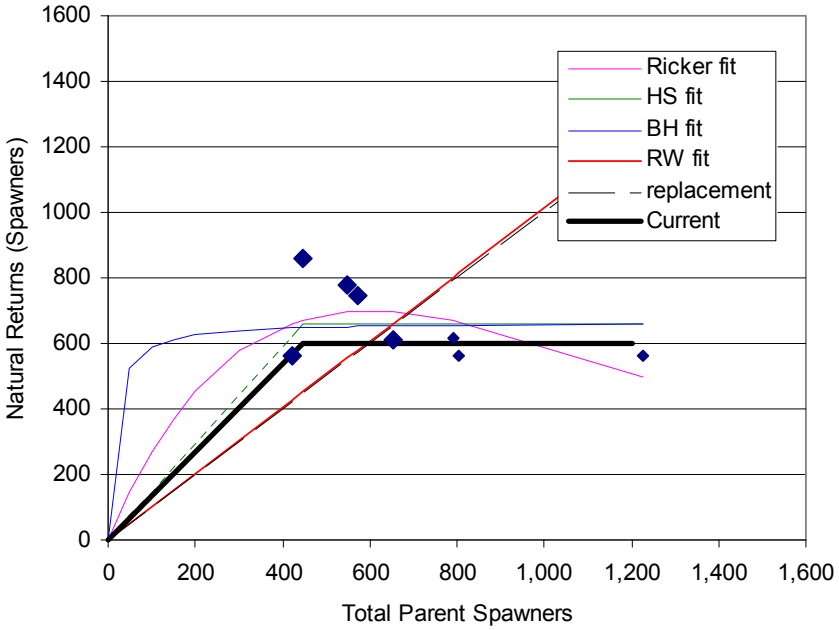


Figure 9. Walla Walla River summer steelhead population stock recruitment curves. Bold points were used in estimating the current productivity. Data were adjusted for marine survival. Function labeled "current" is a Hockey Stick function derived by fixing the slope of the ascending limb at the geometric mean productivity at low to moderate abundance (Table 2) and fitting a capacity estimate to the data series.

APPENDIX C

Summary of habitat projects completed within Oregon's Mid-Columbia River steelhead populations on private and public lands from 1995-2005

Data provided by OWEB, USFS, BLM and Watershed Councils

Summary of habitat projects completed within Oregon's Mid-Columbia River steelhead populations on private and public lands from 1995-2005 (data provided by OWEB and USFS).

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
Fifteenmile Creek Population						
20030865	Fifteenmile Cr	Instream habitat enhancement: anchored structures, bank stabilization	4 structures, 0.13 m	2003	Wasco SWCD	$112,355.00
20030866	Mosier, Chenowith	Upland	6,000 ac	2003	Wasco SWCD	$95,518.00
20030867		Upland	?	2003	Wasco County SWCD	$1,297.00
20030868		Upland	23 ac	2004	Wasco SWCD	$5,460.00
20030869	Lucky Canyon	Upland	4 ac	2003	Wasco County SWCD	$3,906.00
20020839	Fifteenmile Cr, trib of	Weather stations	?	2002	Wasco County SWCD	$46,194.00
20030871	Threemile Cr	Upland	6 ac	2003	Wasco County SWCD	$6,199.00
20030872	Brown's Cr	Upland	12 ac	2003	Wasco County SWCD	$1,263.00
20030873	Lucky Canyon	Upland erosion control, planted	1 ac	2003	Wasco County SWCD	$542.00
20030874	Brown's Cr	Upland erosion control	80 ac	2003	Wasco County SWCD	$6,522.00
20030875	Chenowith Cr	Upland	7 ac	2003	Wasco County SWCD	$1,969.00
20030876	Threemile Cr	Upland erosion control and planting	2 ac erosion, 8 ac planted	2003	Wasco County SWCD	$1,371.00
20030877	Fifteenmile Cr	Riparian fencing	0.59 miles	2001	ODFW	$10,795.00
20030878	Fifteenmile Cr	Riparian fencing	0.5 miles	2001	ODFW	$9,000.00
20030879	Fifteenmile Cr	Riparian fencing	0.5 miles	2003	ODFW	$11,000.00
20030880	Eightmile Cr	Riparian fencing	2.5 miles	2001	ODFW	$43,900.00
20030870	Douglas Hollow	Riparian fencing, upland off-channel watering	0.25 M, 2 off sites	2003	Wasco County SWCD	$9,776.00
20020838	Dry Cr	Off-channel livestock watering, upland erosion control	5 sites	2002	Wasco County SWCD	$12,729.00
990469	Fifteenmile Cr	Off-channel livestock watering	5 sites	1999	ODFW	$12,000.00
20030881	Fivemile Cr	Riparian fencing, off-channel site	0.63 M, 2 sites	2001	ODFW	$12,775.00
1281	Fifteenmile Cr	Instream habitat enhancement: deflectors, bank stabilization; riparian fencing; upland vegetation management	4.5 miles	1996	ODFW	$23,500.00
990734	Mosier Cr, trib of	Peak flow passage improvements, surface drainage improvements, road vacated; fish passage improvements: culvert removed and not replaced	1 structure, 5 ditches, 60 stations, 10 stations, 2 culverts	1999	Longview Fibre Co.	$28,429.00
20020842	Dry Cr & Mosier Cr	Irrigation systems for improved water conservation	30 ac	2001	Wasco County SWCD	$11,997.00
1282	Eightmile Cr	Instream large wood placement, deflectors, bank stabilization, boulder placement; riparian fencing; off-channel livestock watering	3.5 miles	1997	ODFW	$39,000.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20020841	Rock Cr	Irrigation systems for improved water conservation	?	2002	Wasco County SWCD	$1,020.00
20020835	Mosier Cr	Irrigation systems for improved water conservation	20 ac	2002	Wasco County SWCD	$1,281.00
20001121	Rock Cr	Peak flow passage improvements	2 structures	2000	SDS Lumber Co.	$0.00
990467	Fifteenmile Cr	Off-channel livestock watering	?	1999	ODFW	$4,000.00
981112	Mosier Cr	Surface drainage improvements	75 stations	1998	Longview Fibre Co.	$15,072.00
981108	Mosier Cr	Surface drainage improvements	8 culverts, road	1998	Longview Fibre Co.	$16,229.00
991044	Fifteenmile Cr	Instream water rights transfers/leases		1998	Oregon Water Trust	$23,958.00
990472	West Fork Mosier Cr	Peak flow passage improvements, road vacated	1 structure removed	1999	Longview Fibre Co.	$26,942.00
20010913	West Fork Mosier Cr	Peak flow passage improvements, surface drainage improvements, road relocated, road reconstruction	1 structure, 2 cross-drain, 9 culverts	2001	Longview Fibre Co.	$46,114.00
20000725	West Fork Mosier Cr	Peak flow passage improvements, surface drainage improvements	140	2000	Longview Fibre Co.	$62,497.00
990468	Eightmile Cr	Off-channel livestock watering	1 off-channel site	1999	ODFW	$3,500.00
20030882	Fivemile Cr	Riparian fencing, off-channel	1.52 m fence, 2 sites	2002	ODFW	$45,582.00
20040791	Eightmile Cr	Riparian fencing	1.96 m	2004	ODFW	$11,289.00
20040790	Fivemile Cr	Riparian fencing	1.75 m	2004	ODFW	$9,715.00
20040789	Eightmile Cr	Riparian fencing	1 m	2004	ODFW	$8,226.00
20040788	Fifteenmile Cr	Riparian, off-channel	1.5 m, 1 site	2004	ODFW	$21,034.00
20040754	Fifteen Mile Cr	Upland no-till ag	3,501 ac	2005	Wasco SWCD	$284,928.00
20050680	Mill Cr	Upland irrigation improvements	9 ac	2005	Wasco SWCD	$14,351.00
20050678	Fifteenmile Cr	Guzzlers	2	2005	Wasco SWCD	$9,517.00
20050677	Mill Cr	Upland irrigation improvement	5 ac	2005	Wasco SWCD	$1,814.00
20030888	Dry Cr	Riparian fencing, off-channel watering site	0.56 m fence, 1 sites	2003	ODFW	$11,350.00
20030891	Fivemile Cr	Riparian fencing	0.25 m	2003	ODFW	$6,890.00
20030887	Fifteenmile Cr	Riparian fence, off-channel	1.38 m, 3 sites	2003	ODFW	$16,249.00
20030886	Dry Cr	Riparian fencing, off-channel	2.5 m, 8 sites	2002	ODFW	$72,400.00
20030885	Fivemile Cr	Riparian fencing	0.5 m	2001	ODFW	$8,000.00
20030884	Fivemile Cr	Riparian fencing	0.25 m	2001	ODFW	$4,400.00
20030883	Eighmile Cr Rail Hollow	Riparian fencing	1.26 m	2002	ODFW	$22,500.00
20030889	Fifteenmile Cr	Riparian fencing	1.4 m	2003	ODFW	$16,600.00
20030890	Eightmile Cr	Riparian fencing	1.5 m	2003	ODFW	$22,200.00
	Fifteenmile Cr	Underburn	585 ac	1995	USFS	$58,500.00
	Fifteenmile Cr	Instream and floodplain LWD placement	1 RM	1995	USFS	$27,000.00
	Eightmile Cr	Underburn	834 ac	1997	USFS	$83,400.00
	MF Fivemile Cr	Instream and floodplain LWD placement	0.5 RM	1997	USFS	$14,000.00
	Fifteenmile Cr	Floodplain LWD placement	10 ac	1998	USFS	$14,500.00
	MF Fivemile Cr	Replaced round culvert with bridge	1 site	1999	USFS	$150,000.00
	SF Fivemile Cr	Replaced round culvert with bottomless pipe arch	1 site	1999	USFS	$85,000.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
	Ramsey Cr	Instream and floodplain LWD placement	3 RM	2000-2002	USFS	$269,745.00
	Eightmile Cr	Round pipe culvert replacements with bottomless arch culverts	4	2002	USFS	$260,428.00
	Fifteenmile Cr	Instream and floodplain LWD placement	0.25 RM	2003	USFS	$21,000.00
	Ramsey Cr	Underburn	815 ac	2003	USFS	$95,000.00
	Ramsey Cr	Riparian and in-stream restoration	2 mi	2000	USFS Mt. Hood NF	$30,700
Deschutes River Eastside Population						
20050687		Upland irrigation improvement	?	2005	Jefferson SWCD	$5,668.00
990909	Fulton Canyon & Gordon Canyon	Erosion control: terraces & WASCOB systems	78 ac; 15 w/s basins	1999	Sherman SWCD	$21,283.00
20040725	Deschutes, trib of	WASCOB	600 ac	2004	Sherman SWCD	$3,242.00
20030849		Upland	1,080 ac	2003	Sherman SWCD	$6,656.00
20030926		Upland, invasive plants	?	2003	Sherman County Weed District	$14,756.00
990938	Warm Springs R & Skookum Cr	Riparian fencing	9.5 m	1999	Deschutes Resources Conservancy	$153,000.00
20020526		WASCOBs, Terraces	500 ac	2002	Sherman SWCD	$55,603.00
20040753	Fifteen Mile Cr	No-till; off-channel watering; WASCOB	4,173 ac; 5 off; 19 WACOBs	2004	Wasco SWCD	$292,855.00
20010914	Neal Cr & Mosier Cr	Peak flow passage improvements, surface drainage improvements, road relocated, road reconstruction	2 cross-drains, 18 culverts, 60 rocking, 3 relocation, 220 other	2001	Longview Fibre Co.	$47,790.00
20020577	East Fork Neal Cr & Mosier Cr	Surface drainage improvements, road reconstruction	?	2002	Longview Fibre Co.	$24,459.00
20020833		Beaver management	?	1999	Confederated Tribes of Warm Springs Reservation	$21,686.00
20050777	Rock Cr	Road, upland	8 cross-drains, 1 m road seeded, 3 structures	2003	Umatilla SWCD	$84,248.00
20050613	Pine Cr	Upland veg. management	11 ac	2004	Umatilla SWCD	$6,961.00
990910	Gerking Canyon	Erosion control: terraces & WASCOB systems	1,700 ac	1999	Sherman SWCD	$56,852.00
990466	Taylor Lake	Instream air diffuser	1	1999	ODFW	$31,500.00
20030923	Macks Canyon	WASCOB, off-channel watering,	468 ac, 2 off	2003	Sherman SWCD	$34,664.00
20020834	Bakeoven Cr	Off-channel livestock watering, other grazing management, upland erosion control	33 off, 15,527 ft cross fence, 1,048 ac, 77 ac plant, 804 ac no till,14 WASCOB,	2002	Wasco County SWCD	$307,816.00
20040726	Macks Canyon, Area of	Upland terrace, off-channel watering	2,120 ft, 1 site	2004	Sherman SWCD	$3,245.00
545	Willow Cr & Higgins Cr	Bank stabilization	?	1995	Ochoco Lumber Company	$3,500.00
20040724	Elder Cr, Area of	Upland fence	3,749 ft	2004	Sherman SWCD	$4,024.00
20030919	Mud Springs (Trout C. trib)	Up. Irrigation improvement	?	2003	Jefferson County SWCD	$13,165.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20001189	Trout Cr	Boulder placement; grass seeding; fish passage improvements: 3 push-up dams removed and replaced with infiltration galleries	3 dams; unknown boulders, stabilization	1999	Jefferson County SWCD	$98,802.00
20050690	Deschutes R	Upland irrigation improvement	20 ac	2005	Jefferson SWCD	$26,933.00
20040687	Willow Cr	Up. WASCOB, planting	3 ac, 4.5 ac plant	2004	Jefferson SWCD	$13,416.00
20030922	Macks Canyon	WASCOB, off-channel	46 ac, 1 off site	2003	Sherman SWCD	$8,673.00
1201	Willow Cr	Instream habitat enhancement: weirs, bank stabilization; riparian tree planting, riparian fencing; peak flow passage improvements	6 weirs, 14.5 ac treated/planted, 1 mile fence, 20 trees anchored	1997	Central Oregon Small Woodlands Association	$25,700.00
20030924	Buck Hollow Cr	Upland erosion control	30 ac	2003	Sherman SWCD	$2,364.00
20030768	Foley Cr, (Trout C. trib)	Rip. fence, off channel watering site	5 m, 2 sites	2003	Jefferson County SWCD	$56,880.00
20030769	Willow Cr	Upland irrigation improvements	?	2003	Jefferson County SWCD	$25,079.00
20030770	Frog Springs	Upland irrigation improvements	?	2003	Jefferson County SWCD	$7,067.00
20050685	Willow Cr	Riparian planting	2.35 m	2005	Deschutes River Conservancy	$5,162.00
20030928	Buck Hollow Cr	Upland WASCOB, fenced, treated, erosion	300 ac fenced, 16 WASCOB, 565 ac treated, 245 ac erosion, 4 off-channel,	2003	Wasco SWCD	$251,285.00
997	Trout Cr	Instream habitat enhancement: weirs, deflectors, bank stabilization, boulder placement; riparian fencing	40 boulders, 20 deflectors, 5 weirs, 70 miles fence	1997	ODFW	$200,000.00
998	Trout Cr	Fish passage improvements: 1 gravel push-up dam replaced with concrete diversion and fish ladder	1 push-up dam, 1 ladder	1997	ODFW	$67,000.00
20050780	Bakeoven Cr, Buck Hollow Cr	Upland fencing	163,891 ft	2004	Wasco SWCD	$138,517.00
990905	Willow Cr	Riparian fencing	1.5 m	1999	Willow Creek Watershed Council, Jeff County SWCD	$19,150.00
20001129	Tenmile Cr (Trout C. trib)	Upland pasture fencing	989 ac treated, 1 off-channel site	2000	Trout Creek Watershed Council	$57,521.00
980495	Fulton Canyon & Gordon Canyon	Erosion control: terraces & WASCOB systems	13 WASCOB	1998	Sherman SWCD	$28,510.00
990906	Trout Cr	Instream habitat enhancement: anchored structures, bank stabilization	16 anchored structs, 0.066 M stabilized	1999	Trout Creek Watershed Council, Jeff County SWCD	$58,900.00
20020811	Trout Cr	Fish passage improvements: 6 push-up dams removed, replaced with infiltration galleries	6	2002	Jefferson County SWCD	$115,681.00
20010980	Trout Cr	Fish passage improvements: 3 push-up dams removed, replaced with infiltration galleries	3	1998	Jefferson County SWCD	$64,705.00
20010981	Trout Cr	Fish passage improvements: 1 push-up dam removed, replaced with infiltration gallery	1	2002	Jefferson County SWCD	$124,400.00
20040756	Ward Cr	Upland off-channel watering site	1	2004	Wasco SWCD	$3,482.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20020784		Upland erosion control	65 acres	2002	Sherman SWCD	$3,100.00
20050683	Trout Cr	Upland fence, off-channel watering site, grazing management	76 ac fenced, 2 off-channel sites, 76 ac grazing	2005	Jefferson SWCD	$30,975.00
20040747	Newcomb Draw	Upland fence	5,998 ft	2004	Wasco SWCD	$2,925.00
	Auger Cr	Ingram Meadows structure repair, riparian planting and riparian fencing	6 mi	2000	USFS Ochoco NF	$55,425.00
	Trout Cr and tribs	Culvert replacement for flow and fish passage	13 sites	1996-2005	USFS Ochoco NF	$1 million
	Trout Cr watershed	Road closures in Trout watershed along streams and culverts pulled	50 mi	1996-2006	USFS Ochoco NF	$100,000.00
	Trout Cr watershed	Grazing changed from livestock to sheep, improve riparian vegetation to stabilize streambanks		1989	USFS Ochoco NF	
	Auger Creek	Ingram Meadows structure repair, riparian planting and riparian fencing	6 miles	2000	USFS Ochoco NF	$55,425.00
		Culvert replacement for flow & fish passage	13 sites	1996-2005	USFS Ochoco NF	$1 million
	Trout Cr watershed	50 miles of road closures in Trout Watershed along streams and culverts pulled	50 mi	1996-2006	USFS Ochoco NF	$100,000.00
	Trout Cr watershed	Grazing changed from livestock to sheep, improve riparian vegetation to stabilize streambanks		1989	USFS Ochoco NF	
	Deschutes River	Harpham Flat Riparian Exclosure	.5 mile	2000	BLM	$10,000.00
	Trout Cr	OHV area closure fence and rehab to protect riparian area	1 mile fence	2001	BLM	$10,000.00
	Trout Cr	Widen boat ramp, eliminate indiscriminate boat launching to protect riparian area	1 site	2001	BLM	$6,000.00
Deschutes River Westside Population						
20020837	Rock Creek Res. (White R)	Irrigation systems for improved water conservation	?	2002	Wasco County SWCD	$120,717.00
20020836	Boulder Cr	Irrigation systems for improved water conservation	?	2002	Wasco County SWCD	$104,912.00
990939	Deschutes R	Instream habitat enhancement: anchored structures	175 structures	1999	Deschutes Resources Conservancy	$73,141.00
20040748	Threemile Cr	Upland irrigation	4.4 ac	2004	Wasco SWCD	$13,483.00
990940	Deschutes R	Instream water right transfer		1999	Deschutes Resources Conservancy	$425,400.00
20030728	Deschutes R	Riparian treatment	2 M treated	2003	Deschutes SWCD	$11,123.00
20030930	Threemile Cr	Upland irrigation	200 ac	2003	Wasco County SWCD	$23,028.00
20030929	unnamed draw	Wetland creation	?	2003	Wasco County SWCD	$25,730.00
20030927	Deschutes R	Riparian fencing	0.8 miles	2003	Upper Deschutes Watershed Council	$14,110.00
20050781	Jordan Cr (White R)	Riparian fence/plant, upland erosion	1.5 m rip fence, 0.75 m planted, 2 crossings	2004	Wasco SWCD	$49,462.00
20050688	Threemile Cr	Upland irrigation improvements	375 ac	2005	Wasco SWCD	$13,518.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20040755	Tygh Cr	Upland water storage	?	2004	Wasco SWCD	$6,546.00
20040805	Trout Cr	Wetland improvement	0.15 ac	2004	Upper Deschutes Watershed Council	$28,856.00
	Middle and Upper Whychus	Riparian/floodplain protection/road closure	15 mi	2006	USFS Deschutes NF	$29,000.00
	Middle Whychus	Riparian planting	1 mi	2006	USFS Deschutes NF	$2,000.00
	Middle Whychus	Riparian planting	1 mi	1995	USFS Deschutes NF	$1,000.00
	Middle Whychus	Riparian planting	1 mi	2007	USFS Deschutes NF	$1,000.00
	Deschutes River	Bully Point Fence. Construct .75 mile of fencing to improve livestock management in riparian area	.75 mile	2000	BLM	$6,000.00
	Oak Canyon Creek	Riparian fencing exclosure	1 mile	2002	BLM	$10,000.00
996	Whychus Cr	instream water transfers/leases	0.86 cfs	1998	Deschutes Watershed Council	$42,900
990941	Whychus Cr	instream water right transfer	1.81 cfs	1999	Deschutes River Conservancy	$78,950
990942	Whychus Cr	instream water right transfer	0.6 cfs	2000	Deschutes River Conservancy	$105,000
991045	Whychus Cr	instream water rights transfers/leases		1998	Oregon Water Trust	$54,343
991046	Whychus Cr	instream water rights transfers/leases	1.61 cfs	1999	Oregon Water Trust	$17,211
20010982	Whychus Cr	instream water right transfer/lease		2001	Deschutes River Conservancy	$581,698
20020571	Whychus Cr	instream water rights transfer; irrigation systems for improved water conservation	1.5 cfs, 377 acres	2002	Deschutes SWCD	$548,233
20040775	Whychus Cr	upland tree planting, upland vegetation planting	0.1 acre	2004	Deschutes Basin Land Trust	$20,914
20050067	Whychus Cr	instream habitat enhancement: anchored structures	0.75 mile	2001	ODFW	$6,262
20060760	Whychus Cr	instream water right transfers/leases	1.2 cfs	2006	Deschutes River Conservancy	$914,000
20020862	Tumalo Cr	irrigation systems for improved water conservation		2002	Tumalo Irrigation District	$1,350,000
20020863	Tumalo Cr	irrigation systems for improved water conservation		2002	Tumalo Irrigation District	$760,000
20050821	Tumalo Cr			2004	Tumalo Irrigation District	$1,180,695
20060534	Deschutes R		0.09	2006	Upper Deschutes Watershed Council	$9,686
20040805	Trout Cr	wetland improvement	0.15 acre	2004	Upper Deschutes Watershed Council	$28,856
20050779	Tumalo Cr			2003	Tumalo Irrigation District	$1,002,984
20060532	Captain Jack Cr	riparian tree planting, riparian fencing, riparian vegetation planting;	4 acres	2006	Upper Deschutes	$19,080

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		off-channel livestock watering			Watershed Council	
20060533	Trout Cr	wetland restoration, wetland invasive plant control	28 acres	2006	Upper Deschutes Watershed Council	$35,003
20060535	Whychus Cr	instream water right transfers/leases	2.22 cfs	2005	Deschutes River Conservancy	$143,291
20070030	Tumalo Cr			2007	Upper Deschutes Watershed Council	$541,694
996	Whychus Cr	instream water transfers/leases	0.86 cfs	1998	Deschutes Watershed Council	$42,900
990941	Whychus Cr	instream water right transfer	1.81 cfs	1999	Deschutes River Conservancy	$78,950
990942	Whychus Cr	instream water right transfer	0.6 cfs	2000	Deschutes River Conservancy	$105,000
991045	Whychus Cr	instream water rights transfers/leases		1998	Oregon Water Trust	$54,343
991046	Whychus Cr	instream water rights transfers/leases	1.61 cfs	1999	Oregon Water Trust	$17,211
20010982	Whychus Cr	instream water right transfer/lease		2001	Deschutes River Conservancy	$581,698
20020571	Whychus Cr	instream water rights transfer; irrigation systems for improved water conservation	1.5 cfs, 377 acres	2002	Deschutes SWCD	$548,233
20040775	Whychus Cr	upland tree planting, upland vegetation planting	0.1 acre	2004	Deschutes Basin Land Trust	$20,914
20050067	Whychus Cr	instream habitat enhancement: anchored structures	0.75 mile	2001	ODFW	$6,262
20060760	Whychus Cr	instream water right transfers/leases	1.2 cfs	2006	Deschutes River Conservancy	$914,000
20020862	Tumalo Cr	irrigation systems for improved water conservation		2002	Tumalo Irrigation District	$1,350,000
20020863	Tumalo Cr	irrigation systems for improved water conservation		2002	Tumalo Irrigation District	$760,000
20050821	Tumalo Cr			2004	Tumalo Irrigation District	$1,180,695
20060534	Deschutes R		0.09	2006	Upper Deschutes Watershed Council	$9,686
20040805	Trout Cr	wetland improvement	0.15 acre	2004	Upper Deschutes Watershed Council	$28,856
20050779	Tumalo Cr			2003	Tumalo Irrigation District	$1,002,984
20060532	Captain Jack Cr	riparian tree planting, riparian fencing, riparian vegetation planting; off-channel livestock watering	4 acres	2006	Upper Deschutes Watershed Council	$19,080
20060533	Trout Cr	wetland restoration, wetland invasive plant control	28 acres	2006	Upper Deschutes Watershed Council	$35,003

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20060535	Whychus Cr	instream water right transfers/leases	2.22 cfs	2005	Deschutes River Conservancy	$143,291
20070030	Tumalo Cr			2007	Upper Deschutes Watershed Council	$541,694
Crooked River Population						
992	Mill Cr	Riparian fencing	0.33 mile	1996	Central Oregon Small Woodlands Association	$1,100
994	Lawson Cr	Riparian tree planting, riparian fencing; off-channel livestock watering; legacy road improvements	0.28 mile	1997	Dixie Meadows Co.	$8,225
	McKay Creek	Riparian fencing	1.5 mile	1998	ODFW R&E	$59,250
	South Fork Crooked R.	Riparian fencing	3.0 mile	1998	ODFW R&E	$93,250
	Wolf Cr	Riparian fencing	1.75 mile	1998	ODFW R&E	$57,815
995	Lawson Cr	Riparian tree planting, riparian fencing; off-channel livestock watering, upland vegetation management	3.5 mile	1995	Dixie Meadows Co.	$28,700
980009	Cadle, Wolf, Boardtree, Veazie, Crusher, Tamarack, Sheep, South Fork Wolf crks	Instream large wood placement; riparian fencing; livestock removal, livestock exclusion; road relocated; fish passage improvements: 3 culverts replaced	,0.75 riparian,10 mile instream,3 crossing	1998	U.S. Timberlands	$16,300
981101	Mill Cr & McKay Cr	Instream large wood placement, anchored log structures, weirs, deflectors; riparian tree planting, riparian fencing	2.5 mile instream, 4 mile fence	1998	ODFW	$22,125
990735	Mill Cr	Instream habitat enhancement: anchored structures, weirs, deflectors, boulder placement, bank stabilization	1 mile instream, riparian fence	2000	ODFW	$41,000
990804	Dixie Cr	Riparian fencing; grazing management: deferred grazing		2000	U.S. Timberlands	$10,530
990805	South Fork Wolf Cr	Peak flow passage improvements, road vacated	2 crossings	1999	U.S. Timberlands	$4,767
990806	Cadle Cr	Road closed		1999	U.S. Timberlands	$16,321
20001144	Ochoco Cr	Instream habitat enhancement: deflectors, natural boulder placement; riparian tree planting, riparian fencing	2 miles	2000	Crook SWCD	$104,592
	Crooked River (near Post)	Riparian fencing, CREP	3 miles	2000	ODFW, NRCS	$150,000
20010956	Bear Cr	Fish passage improvements: 1 culvert with weirs installed below outlet	1 crossing, 1 mile	2001	Crook County Road Department	$133
20010957	Newsome Cr	Fish passage improvements: 3 culverts with weirs installed below outlet	3 crossing, 4 miles	2000	Crook County Road Department	$3,200
20010958	South Fork Crooked R, trib of	Fish passage improvements: 1 culvert with weirs installed below outlet	1 crossing, 6 miles	2000	Crook County Road Department	$1,637
20010959	Lawson Cr	Road vacated, road relocated		2001	ODF	$613
20010960	McKay Cr	Riparian tree planting, riparian	4.5 miles	2001	Crooked River	$12,500

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		fencing			Watershed Council	
20010961	McKay Cr	Riparian tree planting	1 mile	2001	Crooked River Watershed Council	$1,450
20010962	Crooked R	Riparian tree planting	0.25 mile	2001	Crooked River Watershed Council	$200
20010964	Wolf Cr	Riparian fencing	0.5 mile	2001	Crooked River Watershed Council	$1,500
20010965	Duncan Cr	Riparian tree planting	2 miles	2001	Crooked River Watershed Council	$6,850
20010966	South Fork Crooked R	Riparian fencing	4 miles	2001	Crooked River Watershed Council	$13,000
20010967	Little Bear Cr	Riparian fencing	5 miles	2001	Crooked River Watershed Council	$14,000
20010968	Little Bear Cr	Riparian tree planting	4 miles	2001	Crooked River Watershed Council	$2,100
20010969	Bear Cr	Riparian tree planting	4 miles	2001	Crooked River Watershed Council	$1,000
20010970	Ochoco Cr	Riparian tree planting	0.5 mile	2001	Crooked River Watershed Council	$500
20010971	Mill Cr	Riparian fencing	0.5 mile	2001	Crooked River Watershed Council	$1,500
20010972	Mill Cr	Riparian tree planting, riparian fencing	0.5 mile	2001	Crooked River Watershed Council	$2,000
20010973	Mill Cr	Riparian fencing	1 mile	2001	Crooked River Watershed Council	$2,500
20010974	Mill Cr	Riparian tree planting, riparian fencing	1 mile	2001	Crooked River Watershed Council	$2,650
20010975	Ochoco Cr	Riparian tree planting	0.5 mile	2001	Crooked River Watershed Council	$1,100
20010976	Ochoco Cr	Riparian tree planting	0.5 mile	2001	Crooked River Watershed Council	$300
20011142	Mill Cr & Allen Cr	instream habitat enhancement: anchored structures, full spanning weirs, deflectors, bank stabilization; riparian tree planting, riparian fencing	2 miles	2001	ODFW	$55,000
20020573	Mill Cr	instream habitat enhancement: anchored structures, engineered structures: full spanning weirs, deflectors	1 mile	2002	ODFW, Crooked River Watershed Council	$37,600
20020574	Crooked R/ Shotgun Cr/ Pine Cr	instream natural boulder placement; engineered structures: deflectors; riparian tree planting, riparian fencing; off-channel livestock	0.25 mile, 2.5 miles, 100 acres	2002	Crooked River Watershed Council	$63,993

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		watering, noxious weed control				
20020575	Wickiup Cr	wetland improvement	5 acres	2002	Private Landowner	$25,147
20020854	Bear Cr	off-channel livestock watering, other grazing management, upland erosion control	25 acres	2002	Crook SWCD	$16,681
20020855	Pine Cr	upland erosion control	200 acres	2002	Crook SWCD	$21,013
20020856	Ochoco Cr	natural boulder placement; riparian fencing	0.7 mile	2002	Crook SWCD	$11,822
20020864		off-channel livestock watering		2002	Bedortha Ranches, Inc.	$10,717
20020868	Eagle Cr	upland vegetation management: juniper removal	40 acres	2002	Crook SWCD	$2,300
20030717	Freeman Cr	instream habitat enhancement: weirs; gss (410 pc)	0.75 mile	2003	Crook SWCD	$14,736
20030719	McKay Cr	fish passage improvements: 1 fish ladder installed, 2 flash boards modified	14 miles	2003	Crooked River Watershed Council	$188,727
20030720	McKay Cr	Instream habitat enhancement: anchored structures, deflectors; riparian tree planting, riparian fencing	0.3 mile	2003	Crooked River Watershed Council	$10,926
20030721	McKay Cr	Deflectors, channel alteration; riparian tree planting, riparian fencing	1.5 miles	2003	Crooked River Watershed Council	$93,650
	Little McKay Cr	Instream boulder and large wood placement, riparian protection	1.7 miles	2003	US Forest Service	$183,135
20030722	Mill Cr	Instream habitat enhancement: anchored structures, weirs, deflectors	1 mile	2002	Crooked River Watershed Council	$17,911
20030723	Duncan Cr	Riparian tree planting, riparian fencing; other upland activity; fish passage improvement: other diversions modified	0.3 mile, 4 mile hab	2003	Crooked River Watershed Council	$34,875
20030724	Mill Cr	Riparian tree planting, riparian fencing, water gap development	0.3 mile	2002	Crooked River Watershed Council	$6,642
20030725	Mill Cr	Water gap elimination; irrigation systems for improved water conservation	0.2 mile	2002	Crooked River Watershed Council	$3,329
20030726	South Fork Crooked R	Riparian tree planting, riparian fencing	2.3 miles	2003	Crooked River Watershed Council	$12,259
20030762		Upland vegetation management (juniper control), other upland activity	20 miles	2003	Crook SWCD	$1,658
20030763	Japanese Cr	Off-channel livestock watering		2003	Crook SWCD	$12,987
20030764	Duncan Cr	Riparian tree planting	0.7 mile	2003	Crooked River Watershed Council	$6,950
20030765	McKay Cr	Riparian fencing	1 mile	2003	Crooked River Watershed Council	$13,680
20030921	Lost Cr	Riparian tree planting, riparian fencing, riparian invasive plant control; peak flow passage improvements, other road activity	1.4 mile	2002	The Nature Conservancy	$54,449
20040656	Long Hollow Cr	Upland grazing management, upland vegetation management, upland vegetation planting	200 acres	2004	Crook SWCD	$17,524

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20040657	Clover Cr	Off-channel livestock watering, upland erosion control		2004	Crook SWCD	$13,839
20040658	Wickiup Cr	Off-channel livestock watering		2004	Crook SWCD	$7,956
20040659	Long Hollow Cr	Upland vegetation management	100 acres	2004	Crook SWCD	$5,244
20040772	Crooked R	Riparian invasive plant control; upland invasive plant control	5.5 miles	2003	Crooked River Weed Management Area	$185,906
20040773	Crooked R	Riparian tree planting, riparian fencing; off-channel livestock watering	0.5 mile	2003	Crooked River Watershed Council	$57,270
20040906	Pine Cr	Upland vegetation management (juniper control), upland vegetation planting	680 acres	2003	Crook SWCD	$40,686
20040909	Little Bear Cr	Off-channel livestock watering		2003	Crooked River Watershed Council	$44,727
20040910	McKay Cr	Off-channel livestock watering		2003	Crooked River Watershed Council	$31,551
20040911	Camp Cr	Off-channel livestock watering		2003	Crooked River Watershed Council	$7,690
20040912	Wolf Cr	Off-channel livestock watering		2003	Crooked River Watershed Council	$20,062
20040913	McKay Cr	Instream anchored habitat structure placement, rock/boulder flow deflector installed, riparian tree planting, riparian fencing, peak flow passage improvements	0.5 mile	2004	Crooked River Watershed Council	$109,000
20050048	South Fork Crooked R	Riparian tree planting	3 miles	2004	ODFW	$5,500
20050685	Willow Cr	Riparian tree planting	2.35 miles	2005	Deschutes River Conservancy	$5,162
20050686	Shotgun Cr	Off-channel livestock watering, upland vegetation management, upland vegetation planting	300 acres	2005	Crook SWCD	$44,931
20050693	McKay Cr	Irrigation system improvement	50 acres	2005	Crook SWCD	$10,550
20050697	Crooked R	Riparian tree planting, riparian fencing, bank sloping/floodplain bench creation	0.5 mile	2005	Crooked River Watershed Council	$29,500
20050698	Crooked R	Instream habitat enhancement: deflectors; riparian tree planting, riparian fencing, sloping/floodplain bench creation	2 miles	2005	Crooked River Watershed Council	$162,300
20050699	Crooked R	Riparian tree planting, riparian fencing, bank sloping/floodplain bench creation	0.5 mile	2005	Crooked River Watershed Council	$39,300
20050700	Crooked R	Riparian tree planting, riparian fencing	1 mile	2005	Crooked River Watershed Council	$32,500
20050701	Crooked R	Instream habitat enhancement: deflectors; riparian tree planting, bank sloping/floodplain bench creation	0.5 mile	2005	Crooked River Watershed Council	$33,400
20050702	Crooked R	Riparian tree planting, bank sloping/floodplain bench creation	0.25 mile	2005	Crooked River Watershed	$25,000

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
					Council	
20050703	Mill Cr	Other instream activity; irrigation system improvement		2005	Crooked River Watershed Council	$29,466
20050797	Marks Cr	Main stream channel modified/created, instream rock weirs installed, riparian tree planting, riparian fencing	0.75 mile	2005	Crooked River Watershed Council	$37,224
20050798	Marks Cr	Main stream channel modified/created, instream rock weirs installed, riparian tree planting, riparian fencing	1 mile	2005	Crooked River Watershed Council	$58,775
20050799	Marks Cr	Fish passage improvements: other diversions modified; irrigation diversions with fish screens installed	15 mile hab	2005	Crooked River Watershed Council	$44,250
20060540	North Fork Beaver Cr	Grazing management, upland fencing	1200 acres	2006	Crook SWCD	$24,464
20060542	Little Bear Cr	Stream bank stabilized: bank resloped	0.1 mile	2006	Crooked River Watershed Council	$14,538
20060543	South Fork Crooked R	Upland fencing	38 acres	2006	Crooked River Watershed Council	$5,429
20060544	Marks Cr	Riparian tree planting	1 mile	2006	Crooked River Watershed Council	$10,620
20060545	McKay Cr	Riparian tree planting	0.5 mile	2006	Crooked River Watershed Council	$5,430
20060546	Little McKay Cr	Rock/boulder flow deflector installed, instream rock weirs installed, instream large wood placement; riparian tree planting; other upland activity; peak flow passage improvements	2 crossing, 1 mile	2006	Crooked River Watershed Council	$165,599
20060547	Crooked R	Irrigation system improved: tailwater collection system improved	0.2 acre	2006	Crooked River Watershed Council	$6,749
20060548	Crooked R	Riparian tree planting	2.5 miles	2006	Crooked River Watershed Council	$22,572
20060549	McKay Cr	Other instream activity; riparian tree planting, riparian fencing; off-channel livestock watering	1 mile	2006	Crooked River Watershed Council	$47,170
20060550	Mill Cr	Other instream activity; riparian tree planting, riparian fencing	1 mile	2006	Crooked River Watershed Council	$22,347
20060551	Mill Cr	Instream rock weirs installed, other instream activity; riparian tree planting, riparian fencing; off-channel livestock watering	1 mile	2006	Crooked River Watershed Council	$41,648
20060770	Ochoco R, trib of	Upland vegetation management (juniper control)	20 acres	2004	Crook SWCD	$1,928
20070027	Crooked R	Other instream activity	1 splitter wall	2007	Crooked River Watershed Council	$292,440
20070496	Pine Cr	Upland vegetation planting	100 acres	2007	Crook SWCD	$4,470
20070497	Shotgun Cr	Upland vegetation planting	200 acres	2007	Crook SWCD	$8,549

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20070498	No Name Cr	Upland erosion control, upland vegetation management (juniper control)	50 acres	2007	Crook SWCD	$13,387
20070499	Yank Gulch	Off-channel livestock watering, water/sediment control basins	40 acres	2007	Crook SWCD	$13,311
20070500	Ochoco Cr	Instream boulder placement, instream rock flow deflectors installed, stream bank stabilized: bioengineering	0.02 mile	2007	Crook SWCD	$4,120
20070501	Wolf Cr	Riparian fencing	0.5 mile	2007	Crook SWCD	$6,718
20070502	Long Hollow Cr	Upland vegetation management (juniper control), upland vegetation planting	125 acres	2007	Crook SWCD	$9,859
20070503	Bear Cr	Off-channel livestock watering		2007	Crook SWCD	$13,884
20070504	Pine Cr	upland vegetation planting	50 acres	2007	Crook SWCD	$4,767
20070505	Newsome Cr	upland vegetation planting	45 acres	2007	Crook SWCD	$3,467
20070506		upland vegetation management (juniper control)	65 acres	2008	Crook SWCD	$6,503
20070507	Johnson Cr	upland vegetation management (juniper control)	50 acres	2008	Crook SWCD	$6,470
20070538	McKay Cr & Mill Cr	riparian tree planting	2 miles	2007	Crooked River Watershed Council	$12,500
	McKay Cr	instream boulder and wood placement, riparian protection	4 miles	2007	US Forest Service	$144,825
20070539	South Fork Crooked R	riparian fencing, other upland activity	0.36 mile	2007	Crooked River Watershed Council	$17,504
20070540	Lower Crooked R	stream bank stabilized; riparian tree planting	0.06 mile	2007	Crooked River Watershed Council	$13,073
20070541	South Fork Beaver Cr	stream bank stabilized, riparian vegetation planting; off-channel livestock watering sites developed, Livestock stream access/crossing created or improved, upland fencing, upland vegetation management (juniper control)	25 miles	2007	Crooked River Watershed Council	$513,425
20070749	Lost Cr	fish ladder installed	3 miles hab	2006	The Nature Conservancy	$237,693
Lower Mainstem John Day Population						
20040813	John Day R	Riparian fencing	2 m	2002	ODFW	$12,400.00
20050666	Ferry Canyon	Upland veg management	360 ac	2005	Gilliam SWCD	$15,769.00
20040816	John Day R	Riparian fencing	0.25 m	1997	ODFW	$1,750.00
20050665	Coyote Canyon Spring	Upland wildlife	1 ac	2005	Gilliam SWCD	$468.00
20040759	Parrish Cr	Upland fence, off-channel	280 ac, 1 site	2003	Wheeler SWCD	$13,369.00
20040779	Rock Cr, Hay Cr, & John Day R	Upland off-channel watering site	4 sites	2004	Gilliam-East John Day Watershed Council	$54,955.00
20050663	Lonerock Cr	Upland	80 ac	2005	Gilliam SWCD	$3,926.00
20050662	Lost Valley Cr	Instream, riparian planting	5 weirs, 0.03 m planting	2005	Wheeler SWCD	$4,731.00
20040811	Lake Cr	Riparian fencing	2 m	2002	ODFW	$12,400.00
990741	Lake Cr	Fish passage improvements: culvert	1 culvert	1998	Wheeler County	$10,300.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		upgraded				
20050668		Upland terracing	6,362 ft	2005	Sherman SWCD	$7,446.00
20040809	Johnny Cr	Riparian fencing	1 m	2002	ODFW	$5,000.00
20040810	Lake Cr	Riparian fencing	1.25 m	2002	ODFW	$12,500.00
20040815	John Day R	Riparian fencing	0.33 m	1997	ODFW	$2,310.00
20020786		Other grazing management: fencing	?	2002	Sherman SWCD	$5,008.00
20040730	Cottonwood Canyon	Off-channel watering site	1	2004	Sherman SWCD	$2,832.00
20040731	Fulton Canyon	Upland WASCOB	440 ac	2004	Sherman SWCD	$2,604.00
20040732	Bell Canyon	Upland fencing	600 ac	2004	Sherman SWCD	$6,894.00
20020830	Pine Cr	Off-channel livestock watering	8	2002	Wheeler SWCD	$8,614.00
20020829	Little Muddy Cr	Off-channel livestock watering	1	2002	Wheeler SWCD	$14,102.00
20050670		Upland terracing	7,765 ft	2005	Sherman SWCD	$7,603.00
20020790	West Branch Bridge Cr	Upland vegetation management: juniper control	160 ac	2002	Wheeler SWCD	$10,700.00
20011016	Rock Cr	Fish passage improvements: 1 culvert retrofitted	1	2000	ODOT	$15,000.00
20020788	Nelson Cr, trib of	Riparian juniper removal; other grazing management: planned livestock grazing, upland vegetation management: juniper control	0.25 m, 10 ac	2002	Wheeler SWCD	$1,950.00
990740	Alder Cr	Riparian tree planting, riparian fencing	0.25 m fenced, 1.21 ac planted	1999	Wheeler County	$400.00
20050669		WASCOB	2	2005	Sherman SWCD	$1,254.00
20040826	John Day R	Riparian fencing	0.27 m	1998	ODFW	$1,890.00
990907	several	Riparian tree planting; reseeding/brush harvest, erosion control: grassed waterways	0.02 m, 6 ac riparian planted, 452 ac upland treated	1999	Sherman SWCD	$62,263.00
20040757	Cove Cr	Off-channel site	5	2004	Wheeler SWCD	$6,775.00
20040758	Alder Cr, trib of	Upland irrigation	5.5 ac	2004	Wheeler County	$2,799.00
20050667	East Fork Thirty Mile Cr	Riparian fencing	4.17 m	2005	Gilliam SWCD	$38,130.00
20020582	Rock Cr	Fish passage improvements: 1 push-up dam permanently removed and replaced with permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$32,160.00
20020789	Nelson Cr	Other grazing management	19 ac	2002	Wheeler SWCD	$2,550.00
20010883	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with pump station	1	2001	Grant SWCD	$65,232.00
20001169	Rock Cr	Instream habitat enhancement: anchored structures, weirs, deflectors, off-channel habitat	2 weirs, 2 deflectors, 1 side channel (50 ft), 1 off-channel site	1996	Morrow County Public Works	$76,404.00
20010881	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with pump station	1	2001	Grant SWCD	$74,641.00
20040938	Mountain Cr	Instream habitat enhancement: anchored structures	0.32 m	2004	ODFW	$3,000.00
20020840	John Day R	Irrigation systems for improved water conservation	81 ac	2002	Wasco County SWCD	$20,122.00
20040931	John Day R	Fish passage	1	2004	Grant SWCD	$90,321.00
20040927	John Day R	Fish passage	2	2004	Grant SWCD	$35,026.00
20040926	Badger Cr	Fish passage	4	2004	Grant SWCD	$43,025.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20040822	John Day R	Riparian fencing	1.25 ac	1998	ODFW	$6,250.00
20040923	West Branch Bridge Cr	Fish passage – push-up dam, irrigation dam	1 dam, 67 ac	2004	Wheeler SWCD	$104,021.00
20040839	Alder Cr	Riparian fencing	0.26 m	2001	ODFW	$710.00
20010884	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with pump station	1	2001	Grant SWCD	$115,803.00
20020599	Gauge Cr	Upland vegetation management: juniper control, grass seeding	49 ac	2002	Wheeler SWCD	$11,686.00
20020598	West Branch Bridge Cr	Livestock exclusion, upland vegetation management: juniper control, brush removal, reseeding	3600 ft cross fence, 11.5 ac veg. mang, 49 ac juniper, 8 ac brush	2002	Wheeler SWCD	$9,988.00
20020597	West Branch Bridge Cr	Fish passage improvements: 1 culvert replaced with open bottom arch culvert	1	2002	Wheeler SWCD	$24,145.00
20020596	Pine Cr	Instream habitat enhancement: anchored structures, 'V' structures; fish passage improvements: 1 culvert removed and not replaced, 1 irrigation ditch removed	21 anchored structures, 3 v structures	2002	Wheeler SWCD	$69,000.00
20010885	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with permanent diversion structure	1	2001	Grant SWCD	$52,204.00
20010886	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with permanent diversion structure	1	2001	Grant SWCD	$33,740.00
20010887	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with permanent diversion structure	1	2001	Grant SWCD	$29,970.00
20040924	Mountain Cr	Riparian planting	0.5 m	2004	Wheeler SWCD	$3,950.00
20040842	Cottonwood Cr	Riparian fencing	0.25 m	1998	ODFW	$2,500.00
20040819	John Day R	Riparian fencing	0.67 m	1998	ODFW	$3,330.00
20040820	Dry Fork Thirtymile Cr	Riparian fencing	0.02 m	1998	ODFW	$2,800.00
20040729	Jackknife, Watershed	Upland erosion control	60 ac	2004	Sherman SWCD	$6,451.00
20050661	Lost Valley Cr	Road	2 culverts	2005	Wheeler SWCD	$3,751.00
20020785		Off-channel livestock watering	1	2002	Sherman SWCD	$6,212.00
20040827	John Day R	Riparian fencing	1.3 m	1998	ODFW	$2,324.00
20010910	West Branch Bridge Cr	Riparian fencing; off-channel livestock watering, cross fencing	0.75 m rip fence, 1,320 ft. up. fence	2001	Wheeler SWCD	$9,468.00
20010909	Johnson Cr	Riparian fencing; off-channel livestock watering	0.75 m	2001	Wheeler SWCD	$15,351.00
20040829	John Day R	Riparian fencing	0.83 m	1998	ODFW	$4,166.00
20050659		Riparian fencing, off-channel, WASCOB	2 m fenced, 5 off-channel sites, 6 control basins	2003	Sherman SWCD	$106,385.00
20040828	Lake Cr	Riparian fencing	0.12 m	1998	ODFW	$1,750.00
20010903	John Day R	Riparian fencing	0.68 m	2001	ODFW	$3,400.00
20040841	Johnny Cr	Riparian fencing	0.5 m	1998	ODFW	$5,000.00
20010898	John Day R	Riparian fencing	0.4 m	2000	ODFW	$2,230.00
20010888	John Day R	Fish passage improvements: 1 push-	1	2001	Grant SWCD	$64,844.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		up dam removed, replaced with pump station				
20001125	Rock Cr	Upland erosion control: sediment control basins	4 control basins	2000	Gilliam SWCD	$4,316.00
20001126	Sixmile Canyon & Hay Cr	Upland erosion control	617 ac	2000	Gilliam SWCD	$39,611.00
20001127	John Day R	Riparian fencing; off-channel livestock watering	1.5 m fence, 9 sites	2000	Wheeler SWCD	$29,463.00
990908	Pine Hollow	Off-channel livestock watering, grazing management: cross-fencing, erosion control: sediment basins	9,702 ft fenced, 980 ac WASCOB, 420 ac rip plants, 1 off-channel site	1999	Sherman SWCD	$65,618.00
990937	John Day R	Riparian tree planting, riparian fencing; off-channel livestock watering, irrigation systems for improved water conservation	5 m fenced, 6 ac planted, 3 off-channel sites, 46 ac treated	1999	Wheeler SWCD	$57,128.00
20010889	John Day R	Fish passage improvements: 1 push-up dam removed, replaced with pump station	1	2001	Grant SWCD	$99,950.00
1115	John Day R	Riparian fencing	1 mile	1997	ODFW	$7,000.00
1116	John Day R	Riparian fencing	1 mile	1996	ODFW	$7,000.00
20030841	Lake Cr	Riparian tree planting, riparian fencing	4 m	2003	ODFW	$43,000.00
20030838	Mountain Cr	Instream habitat enhancement: anchored structures	25 structures	2003	ODFW	$3,500.00
20030835	Thirtymile Cr	Upland off-channel watering site	1	2003	Gilliam SWCD	$5,194.00
20030833	Hay Cr	Upland	1 sed. Basin, 1 off-channel site	2003	Gilliam SWCD	$4,266.00
20040831	John Day R	Riparian fencing	0.8 m	1998	ODFW	$5,600.00
1117	John Day R	Riparian fencing	1.25 miles	1997	ODFW	$8,750.00
20030925		WASCOB	50 ac	2003	Sherman SWCD	$4,045.00
1175	Pine Hollow Watershed	Off-channel livestock watering, cross fencing, riparian pasture, erosion control: WASCOB, juniper control	5 ac juniper, 2 sed. Control basins, 4,000 ft terrace, 65 ac planted	1997	Sherman SWCD	$27,200.00
20050694		Upland terracing	7,741 ft	2005	Sherman SWCD	$6,667.00
980496	Pine Hollow & tribs	Off-channel livestock watering, cross fencing, erosion control: terraces & WASCOB	6 sed. Basins, 1 off-channel site, 5,296 ft terrace, 65 ac planted	1998	Sherman & Wasco SWCD	$53,558.00
20030947	Muddy Cr	Fish passage	1 dam	2003	Wasco County SWCD	$55,069.00
20030948	Service Cr	Upland erosion control	65 ac erosion manag. 330 ac fenced, 40 ac juniper	2003	Wheeler SWCD	$19,057.00
20030960		Off-channel watering sites	5	2004	Sherman SWCD	$3,671.00
20040728		Upland sed. Control basins	600 ac	2004	Sherman SWCD	$2,385.00
20030858		Upland sed. Control basins	6	2003	Sherman SWCD	$2,600.00
20050772	John Day R	Upland fence, off-channel watering site	I site	2001	Wheeler SWCD	$14,280.00
20050770	Muleshoe Cr	Riparian fencing, planting	0.5 m fenced, 1	2004	Wheeler SWCD	$10,935.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
			m planted			
20050769	Alder Cr	Upland juniper treatment	360 ac	2003	Wheeler SWCD	$33,684.00
20050768	West Branch Bridge, Bridge, Gable, Nelson, Keyes, Bear, Alder, Pine crks	Upland irrigation, water measuring device	?	2003	Wheeler SWCD	$9,014.00
20050767	Mountain Cr	Riparian planting	0.19 m	2003	Wheeler SWCD	$2,500.00
20050766	Kahler Cr, Corncob Cr	Instream log berm, riparian fencing/planting, juniper	0.78 m fenced, 0.53 m planted, 1 structure, 15 ac juniper treated	2004	Wheeler SWCD	$8,715.00
20030846	Mountain Cr	Instream large wood placement	51 logs	2003	ODFW	$3,200.00
20030859		Off-channel watering site	1 site	2003	Sherman SWCD	$14,566.00
20030847		Upland terrace	35 ac	2003	Sherman SWCD	$1,525.00
20030857		Upland erosion control	6 ac	2003	Sherman SWCD	$3,765.00
20030856		Upland WASCOB	2 sites	2003	Sherman SWCD	$5,876.00
20030854		Upland range	300 ac	2003	Sherman SWCD	$4,481.00
20030853		Upland range	412 ac	2003	Sherman SWCD	$8,400.00
20030851		Upland brush management	135 ac	2003	Sherman SWCD	$8,520.00
20030850		Off-channel watering site	1	2003	Sherman SWCD	$14,037.00
20030832	Lamberson Canyon	Off-channel watering site	1	2003	Gilliam County SWCD	$3,765.00
20030860	Cottonwood Cr	Off-channel watering site	5	2003	Wheeler SWCD	$8,125.00
20050674	West Branch Bridge Cr	Upland juniper, noxious weeds, off-channel watering site	15 ac, 1 site	2005	Wheeler SWCD	$5,641.00
20030834	Stackhouse Canyon	Off-channel watering site	1	2003	Gilliam SWCD	$6,050.00
20020853	John Day R	off-channel livestock watering	1	2002	Gilliam SWCD	$4,562.00
20040712	Holmes Cr	Upland irrigation	25 ac	2005	Monument SWCD	$4,209.00
20020852	John Day R	off-channel livestock watering	1	2002	Gilliam SWCD	$6,725.00
20020851	Rock Cr	irrigation systems for improved water conservation	42 ac	2002	Gilliam SWCD	$12,953.00
20040717	Rood Canyon, area of	Off-channel watering site	1	2004	Morrow SWCD	$12,726.00
20040721		Upland erosion control, WASCOB	75 ac	2004	Sherman SWCD	$2,499.00
20040723		Upland erosion control, WASCOB	1	2004	Sherman SWCD	$5,794.00
20040727		Upland brush management	600 ac	2004	Sherman SWCD	$3,051.00
20040664	Thirty Mile Cr	Off-channel watering site	5	2004	Gilliam SWCD	$7,561.00
981090	John Day R	fish passage improvements: push-up dam removed, replaced with pump	1 structure	1998	Grant SWCD	$109,017.00
	Rock Cr	instream structure removal	1 mile	2000	USFS Ochoco NF	$4,500.00
	Rock Cr	Cutbank (channel morphology) Restoration-instream structure placement	2 miles	2001	USFS Ochoco NF	$11,000.00
	Wheeler Cr	fish passage improvement	3 miles	1997	USFS Umatilla NF	$2,500.00
	Alder Cr	fish passage improvement	2 miles	1997	USFS Umatilla NF	$1,500.00
	Davis Cr	fish passage improvement	1 mile	1997	USFS Umatilla NF	$2,000.00
	Corncob Cr	fish passage improvement	1 mile	1997	USFS Umatilla NF	$1,500.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
	Wheeler Cr	Riparian planting	36 acres	1998	USFS Umatilla NF	$6,300.00
	Wheeler Cr	Riparian planting	14 acres	1999	USFS Umatilla NF	$2,450.00
	Henry Cr - electric	riparian corridor and pasture fencing	0.25	1998	USFS Umatilla NF	$300.00
	Henry Cr - electric	riparian corridor and pasture fencing	0.75	2001	USFS Umatilla NF	$750.00
	EF Bologna Creek	riparian corridor and pasture fencing	2	1997	USFS Umatilla NF	$16,000.00
	Rock Creek	Instream structure removal	1 mi	2000	USFS Ochoco NF	$4,500.00
	Deep Creek	Riparian fencing	5 miles	2000	BLM	$10,000.00
	John Day	Ag field rehabilitation. Control weeds, plant riparian shrubs and cottonwoods	300 ac 2 miles	2000	BLM	$12,000.00
	Bridge Creek	Spring developments provide alternative water sources for cattle	3 springs	2000	BLM	$9,000.00
	Lower mainstem John Day	Wild and Scenic River Management Plan changed season of use for grazing allotments to protect riparian conditions	Tumwater Falls to Service Creek	2001	BLM	Unknown
	Esau Canyon	Pasture development and riparian fencing	11 riparian miles	2003	BLM	$44,000.00
	Cordwood Canyon	Riparian fencing	0.3 mile	2003	BLM	$10,500.00
	Bear Creek	Willow Spring riparian fencing (trib to Bear Creek, then Bridge Creek)	2.7 riparian miles	2003	BLM	$10,000.00
	Lower mainstem John Day	Green Fence #2 riparian fencing	3 miles	2006	BLM	$14,000.00
	Lower mainstem John Day	Stanley ag. Field/John Day River riparian fencing	1 mile	2006	BLM	$8,000.00
Upper Mainstem John Day Population						
20001163	John Day R	fish passage improvements: 1 push-up dam permanently removed	1	2000	Grant SWCD	$60,386.00
981098	John Day R	irrigation systems for improved water conservation	55 acres treated, 2,800 ft pipe	1995	Grant SWCD	$46,778.00
20010882	John Day R	irrigation systems for improved water conservation	161 ac	2001	Grant SWCD	$67,930.00
20001161	John Day R	fish passage improvements: 1 push-up dam permanently removed	1	1999	Grant SWCD	$258,063.00
990719	Canyon Cr	boulder placement; riparian fencing, watergaps	2 water gaps, 0.45 fencing	1995	ODFW	$32,155.00
981097	John Day R	irrigation systems for improved water conservation	37 ac treated, 4,780 ft pipe	1995	Grant SWCD	$94,320.00
20001162	John Day R	fish passage improvements: 1 push-up dam permanently removed	1	2000	Grant SWCD	$60,258.00
20040935	Standard Creek Diversion	Fish passage improvements, push-up dam	1	2004	Grant SWCD	$22,351.00
20020752	Indian Cr	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$20,072.00
20020586	Indian Cr	riparian fencing	0.6 m	2002	ODFW	$6,286.00
20020751	Indian Cr	fish passage improvements: 1 push-up dam permanently removed and	1	2002	Grant SWCD	$20,072.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		replaced with 1 permanent lay-flat stachion diversion structure				
20040934	Dixie Cr	Fish passage, push-up dam	1	2004	Grant SWCD	$13,502.00
20001164	John Day R	irrigation systems for improved water conservation	66 ac	2000	Grant SWCD	$50,836.00
20001165	Indian Cr	fish passage improvements: 2 push-up dams permanently removed	2	2000	Grant SWCD	$30,973.00
20020587	John Day R	irrigation systems for improved water conservation	300 ac	2002	Grant SWCD	$60,982.00
20040830	John Day R	Riparian planting	0.15 m	2002	ODFW	$760.00
20020588	John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with permanent diversion structure	1	2002	Grant SWCD	$24,830.00
20020589	John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$21,675.00
20020590	John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$24,703.00
20020591	John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$23,110.00
20020592	John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent diversion structure	1	2002	Grant SWCD	$31,918.00
20050771	John Day R	Upland irrigation water measuring devises		2002	Grant SWCD	$5,013.00
20040929	John Day R	Fish passage push-up dam	1	2004	Grant SWCD	$58,844.00
1114	Canyon Cr	instream habitat enhancement: boulder placement; riparian tree planting	40 boulders, other not reported	1996	ODFW	$900.00
20040933	John Day R	Upland irrigation improvement	50 ac	2003	Grant SWCD	$24,961.00
20020792	Indian Cr	fish passage improvements: 1 push-up dam removed and replaced with permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$19,057.00
20020791	Indian Cr	fish passage improvements: 1 push-up dam removed and replaced with 4.7 permanent lay-flat station diversion structure	1	2002	Grant SWCD	$19,746.00
20020581	Beech Cr	Riparian fencing	4.7 m	2002	ODFW	$16,402.00
20040928	John Day R	Fish passage push-up dam	2	2004	Grant SWCD	$19,056.00
20040930	Canyon Cr	Fish passage, push-up dam	1	2004	Grant SWCD	$15,090.00
981099	Widows Cr	riparian fencing; fish passage improvements: push-up dam removed, replaced with screened inlet structures	2.1 miles	1995	Grant SWCD	$228,570.00
20040932	John Day R	Fish passage, push-up dams	2	2004	Grant SWCD	$44,664.00
20050673	Grouse Cr	Upland juniper, noxious weeds, plantings	530 ac juniper, 280 ac weeds, 305 ac plant	2005	Grant SWCD	$55,361.00
981085	Indian Cr	riparian fencing	2.68 miles	1998	ODFW	$29,858.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20001157	Grub Cr	riparian fencing	1.6 m	2000	ODFW	$20,656.00
20040823	Widows Cr	riparian fencing	0.25 m	1998	ODFW	$3,500.00
20010890	John Day R	irrigation systems for improved water conservation	66 ac	2001	Grant SWCD	$40,530.00
1122	Widows Cr/John Day R	riparian fencing	3.45 miles	1996	ODFW	$24,150.00
981092	John Day R	fish passage improvements: push-up dam removed, replaced with infiltration gallery	1 structure	1997	Grant SWCD	$61,498.00
20040669	Blue Mountain Ditch, area of	Upland juniper	50 ac	2004	Grant SWCD	$4,601.00
20030939	Deardorf Cr	invasive species removal	?	2003	Grant Weed Control	$1,708.00
20040668	Blue Mtn. Ditch, area of	invasive species removal	75 ac	2004	Grant SWCD	$8,091.00
1120	Canyon Cr	boulder placement; riparian fencing	1 mile, 20 boulders	1996	ODFW	$17,000.00
981084	Indian Cr	fish passage improvements: push-up dam removed, replaced with infiltration gallery	1	1998	Grant SWCD	$17,060.00
20040825	John Day R	riparian fencing	0.6 m	1998	ODFW	$3,030.00
20040812	Laycock Cr	riparian fencing	0.75 m	2003	ODFW	$7,500.00
20040666	McClellan Cr, area of	Upland juniper treatment	150.8 ac	2005	Grant SWCD	$14,556.00
20040665	Laycock Cr, area of	Upland juniper treatment	86.8 ac	2004	Grant SWCD	$7,144.00
20040808	Laycock Cr	riparian fencing	0.5 m	2003	ODFW	$6,000.00
981086	John Day R	riparian fencing; off-channel livestock watering	4 miles, 1 site	1998	ODFW	$46,427.00
20030732	Dads Cr & Dixie Cr	riparian fencing	2.25 m	2003	Grant SWCD	$11,112.00
20030731		Upland treatment	80 ac	2003	Grant SWCD	$5,027.00
981089	John Day R	irrigation systems for improved water conservation	35 ac	1999	Grant SWCD	$69,741.00
981091	John Day R	fish passage improvements: push-up dam removed, replaced with pump	1 pump station, replaced 1,980 ft pipe	1997	Grant SWCD	$136,777.00
20010902	Indian Cr	riparian tree planting, riparian fencing	0.3 m fenced, 4 ac planted	2000	ODFW	$2,400.00
20040837	Dry Cr	Riparian fencing	2 m	1998	ODFW	$11,400.00
20050664		Upland juniper removal	135 ac	2005	Grant SWCD	$12,400.00
20020585	Grub Cr	riparian fencing	0.5 m	2002	ODFW	$5,943.00
20030843	Canyon Cr	riparian fencing	0.5 m	2003	ODFW	$11,500.00
20030842	Canyon Cr/Berry Cr	riparian fencing	1.4 m	2003	ODFW	$18,176.00
981096	John Day R	riparian fencing; fish passage improvements: push-up dam removed, replaced with pump station	0.43 miles, 1 pump station	1996	Grant SWCD	$94,372.00
20030840	John Day R	riparian fencing	0.7 m	2003	ODFW	$15,000.00
20030839	Canyon Cr	riparian fencing	0.25 m	2003	ODFW	$10,000.00
20010901	West Fork Grub Cr	riparian fencing; off-channel livestock watering	1.1 m fencing, 3 sites	2000	ODFW	$23,164.00
20001160	John Day R	fish passage improvements: 1 push-up dam permanently removed	1	1999	Grant SWCD	$61,922.00
20030837	Indian Cr	instream habitat enhancement: anchored structures; riparian fencing	27 structures, 0.5 m fence	2003	ODFW	$13,000.00
20030836	McClellan Cr	Upland juniper treatment	94 ac	2003	Grant SWCD	$7,820.00
20010905	Beech Cr	riparian fencing	1 m	2001	ODFW	$7,910.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
981095	John Day R	irrigation systems for improved water conservation	82 ac, 3 pump stations	1996	Grant SWCD	$103,367.00
20020753	Indian Cr	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1 structure	2002	Grant SWCD	$20,072.00
981094	John Day R	fish passage improvements: push-up dam removed, replaced with permanent structure	1 structure	1996	Grant SWCD	$34,186.00
990723	Indian Cr	boulder placement; riparian fencing, watergaps	86 boulders, 0.3 m fence	1999	ODFW	$8,690.00
981093	John Day R	cross fencing, irrigation systems for improved water conservation; fish passage improvements: push-up dam removed, replaced with infiltration gallery	1 structure	1998	Grant SWCD	$221,457.00
20020583	Canyon Cr	riparian fence maintenance		2002	ODFW	$1,190.00
	Little Pine Creek	Culvert replacement for fish passage	1 culvert	2005	BLM	$25,000.00
	Cottonwood Creek	Riparian fence	1 mile	2006	BLM	$17,000.00
	Little Pine Creek	Re-route valley bottom road; obliterate and re-contour old roadbed	1 mile	2006	BLM	$98,000.00
Middle Fork John Day Population						
20010891	Camp Cr	fish passage improvements: 1 push-up dam removed, replaced with permanent diversion structure	1	2001	Grant SWCD	$32,975.00
20001167	South Fork Long Cr	fish passage improvements: 1 push-up dam permanently removed	1	1999	Grant SWCD	$18,297.00
20001128	Middle Fork John Day R	instream habitat enhancement: off-channel habitat; riparian tree planting; wetland habitat improvements	1 side-channel, 3 ac wetland, 0.006 ac riparian plants	2000	The Nature Conservancy	$12,734.00
20040840	Granite Cr	Riparian fencing	0.8 m	2001	ODFW	$8,750.00
991049	Big Cr, Hawkins Cr, Big Boulder Cr, & Middle Fork John Day R	instream water right transfer/lease		2000	Oregon Water Trust	$136,998.00
20010892	Camp Cr	fish passage improvements: 1 push-up dam removed, replaced with permanent diversion structure	1	2001	Grant SWCD	$35,378.00
990718	Middle Fork John Day R	riparian fencing, watergaps	1.3 m	1996	ODFW	$78,270.00
981087	Middle Fork John Day R	fish passage improvements: push-up dam removed, replaced with pipeline	800 ft of pipe, headgates	1998	Grant SWCD	$21,364.00
1123	Middle Fork John Day R	streambank stabilization; riparian fencing	1.3 miles fenced, 0.5 m stabilized	1996	ODFW	$30,480.00
1121	Middle Fork John Day R	riparian fencing	3.75 miles	1997	ODFW	$26,250.00
1119	Camp Cr	riparian fencing	0.5 miles	1997	ODFW	$7,230.00
990722	Camp Cr	riparian fencing, watergaps	0.5 m fenced, 3 gaps	1997	ODFW	$32,735.00
20010893	Middle Fork John Day R	riparian fencing	5 m	2001	ODFW	$26,250.00
20010894	Paul Cr	riparian fencing	1 m	1999	ODFW	$21,000.00
20020843	Pass Cr	riparian fencing; off-channel livestock watering	0.25 m	2002	North Fork John Day Watershed Council	$26,345.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20040818	Middle Fork John Day R	Riparian fencing	2 m	1996	ODFW	$14,000.00
20020593	Middle Fork John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat station diversion structure	1	2002	Grant SWCD	$31,430.00
20020594	Middle Fork John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1	2002	Grant SWCD	$30,066.00
20040936	Camp Cr	Fish passage	1	2003	Grant SWCD	$12,511.00
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-instream structures and large wood placement	24 miles	1999	USFS Malheur NF	
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-log landing rehabilitation	8 acres	1999	USFS Malheur NF	
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-meadow restoration (seeding, planting, water table restoration)	20 acres	1999	USFS Malheur NF	
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-road decommissioning	43 miles	1999	USFS Malheur NF	
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-riparian planting and caging	20 miles	1999	USFS Malheur NF	
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-instream structures and large wood placement	6 miles	2000	USFS Malheur NF	
	Galena area streams	Summit Fire Recovery and Fish Habitat Rehabilitation-instream structures and large wood placement	12 miles	2001	USFS Malheur NF	$16,100.00
	SE Galena area multiple streams	Summit fire/SE Galena hardwood diversity planting and protection	6 miles	2002	USFS Malheur NF	$57,375.00
	Vinegar Creek	riparian planting	5 miles	2002	USFS Malheur NF	$4,730.00
	Long Creek and MF John Day River	Flood Meadows riparian planting and protection, spring exclosure, streambank protection through large wood placement	1/2 mile each	2003	USFS Malheur NF	$9,900.00
	Long Creek, Coxie Creek, Camp Creek, Lick Creek, West Fork Lick Creek	Riparian Planting, caging, riparian corridor and pasture fencing	3.5 miles	2004	USFS Malheur NF	$96,950.00
	Camp Creek	riparian planting and protection	1 mile	2005	USFS Malheur NF	$9,345.00
	Long Creek and Camp Creek	riparian planting and caging	Long Creek (1 mile), Camp Creek (4 miles)	2006	USFS Malheur NF	$11,343.00
	Little Indian Creek	Riparian corridor fencing	.7 miles	1997	Umatilla NF	$10,800.00
North Fork John Day Population						
990477	Middle Fork Wilkins Cr	peak flow passage improvements,	1	1999	Pioneer Resources, LLC	$150.00
990478	Scaffold Cr	road relocation	3	1999	Pioneer Resources, LLC	$200.00
990479	Wilkins Cr	peak flow passage improvements	6	1998	Pioneer Resources, LLC	$11,000.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
990480	Snake Cr & Camas Cr	peak flow passage improvements, surface drainage improvements	12 structures, 140 stations	1998	Pioneer Resources, LLC	$44,048.00
990481	Fivemile Cr	peak flow passage improvements, surface drainage improvements	1 culvert, 1 structure	1999	Pioneer Resources, LLC	$13,000.00
990482	Wilkins Cr	Voluntary Riparian Tree Retention	?	1999	Pioneer Resources, LLC	$0.00
990717	Camas Cr	instream large wood placement; riparian fencing, watergaps; off-channel livestock watering	2.1 m fenced, 49.7 ac	1995	ODFW	$106,732.00
20040937	Cottonwood Cr	Riparian fencing	3 m	2005	ODFW	$43,000.00
20040714	North Fork John Day R	Off-channel watering site	1	2005	Monument SWCD	$3,385.00
20011133	Camas Cr	riparian tree planting, riparian fencing	1 m	2001	Oregon Parks & Recreation Dept.	$20,973.00
20040709	North Fork John Day R	Riparian fencing	0.5 ac	2003	Monument SWCD	$6,007.00
20011089	North Fork John Day R, trib of	upland erosion control	10 ac	2001	North Fork John Day Watershed Council	$3,350.00
20011017	Porter Cr	fish passage improvements: 1 culvert retrofitted	1 culvert	2000	ODOT	$0.00
20040786	Porter Cr, Johnson Cr, Harrington Cr, & tribs of	Upland fencing, off-channel watering site, road	Bridge, 6 off-channel sites, 2 ac fenced	2005	North Fork John Day Watershed Council	$64,348.00
20040824	North Fork John Day R	Riparian fencing	1.5 m	1998	ODFW	$7,500.00
20010907	North Fork John Day R	fish passage improvements: 1 push-up dam removed, replaced with permanent pumping station	1	2000	North Fork John Day Watershed Council	$35,000.00
990720	Fox Cr	riparian fencing, watergaps; off-channel livestock watering	1 m fenced, 2 gaps, 2 off-channel sites	1995	ODFW	$42,185.00
980965	North Fork John Day R	riparian fencing	0.5 miles, 4.2 ac	1998	North Fork John Day Watershed Council	$3,100.00
20030845	Granite Cr	dredge tail leveling	0.6 m	2003	ODFW	$50,000.00
20030844	Granite Cr	dredge tail leveling	0.35 m	2003	ODFW	$40,000.00
1118	Fox Cr	riparian fencing	0.5 m	1996	ODFW	$7,000.00
1406	Pine Cr	riparian tree planting	0.25 m, 1.2 ac	1997	North Fork John Day Watershed Council	$350.00
1407	North Fork John Day R	riparian tree planting	0.25 m	1996	North Fork John Day Watershed Council	$150.00
1408	Cottonwood Cr	riparian tree planting	0.13 m	1997	North Fork John Day Watershed Council	$200.00
1409	North Fork John Day R	bank stabilization	0.5 m	1997	North Fork John Day Watershed Council	$7,800.00
980008	North Fork John Day R	fish passage improvements: push-up dam removed, replaced with permanent pumping station	1	1998	North Fork John Day Watershed Council	$21,770.00
20040711	Board Cr	Upland erosion control	120 ac	2004	Monument SWCD	$9,734.00
20030943	Portugese Canyon	Upland juniper	150 ac	2003	Monument SWCD	$6,790.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
20040713	Pine Cr	Upland juniper	60 ac	2005	Monument SWCD	$5,945.00
980966	North Fork John Day R	riparian fencing	0.125	1998	North Fork John Day Watershed Council	$1,000.00
980967	North Fork John Day R	instream habitat enhancement: weirs	4 structures	1998	North Fork John Day Watershed Council	$8,900.00
980968	North Fork John Day R	fish passage improvements: push-up dam removed, replaced with permanent pumping station	1 dam	1998	North Fork John Day Watershed Council	$21,770.00
20030944	Kingsely Cr	Riparian and upland	0.5 m rip fence, 40 ac upland fenced, 19 ac treated	2003	Monument SWCD	$8,586.00
20030945	Upper Wilson Cr	riparian fencing	2.08 m	2003	North Fork John Day Watershed Council	$15,600.00
990721	Fox Cr	anchored structures; riparian fencing, watergaps	0.3 m fenced, 2 water gaps	1995	ODFW	$9,628.00
20040710	Wall Cr	Upland erosion, off-channel watering site	37 ac, 1	2004	Monument SWCD	$10,466.00
20010906	North Fork John Day R	fish passage improvements: 1 push-up dam removed, replaced with permanent pumping station	1	2000	North Fork John Day Watershed Council	$32,000.00
20030942	Alkali Cr	Off-channel watering sites	4	2003	Monument SWCD	$9,818.00
20040836	North Fork John Day R	Riparian fencing	0.25 m	1998	ODFW	$860.00
20001158	Granite Cr	riparian tree planting, riparian habitat enhancement: dredge pile leveling, floodplain restoration	1.8 m fenced, 12 ac planted	2000	ODFW	$179,754.00
20050658	Snipe Cr	Riparian fencing	0.25 m	2005	Umatilla SWCD	$5,248.00
20010895	Fox Cr	riparian fencing; off-channel livestock watering	1.1 m, 1 site	1999	ODFW	$10,000.00
20010896	North Fork John Day R	riparian fencing; off-channel livestock watering	0.5 m, 1 site	1999	ODFW	$3,000.00
20010899	North Fork John Day R	riparian fencing	1m	2000	ODFW	$5,000.00
20040940	Cottonwood Cr	Riparian fencing	0.8 m	2004	Grant SWCD	$7,788.00
20040939	Cottonwood Cr	riparian fencing	0.26 m	2005	ODFW	$70,000.00
20020584	Granite Cr	dredge pile leveling		2002	ODFW	$52,614.00
	Fox Cr	Watershed Improvement-Riparian Planting	4 miles of stream	2002	USFS Malheur NF	$10,020.00
	Auger Creek	Ingram Meadows structure repair, riparian planting and riparian fencing	6 miles	2000	USFS Ochoco NF	$55,425.00
	Granite and Clear Creeks	floodplain dredge tailings redistribution	3.3 miles	2000	USFS Umatilla NF	$100,000.00
	SF Desolation Creek	riparian conifer planting for fire recovery-Summit Fire	1 mile	2000	USFS Umatilla NF	$14,000.00
	Granite and Clear Creeks		3 miles	2001	USFS Umatilla NF	$134,500.00
	Clear Cr	floodplain dredge tailings redistribution	1 mile	2002	USFS Umatilla NF	$56,600.00
	Clear Cr	riparian planting and tubing	2 miles	2003	USFS Umatilla NF	$13,500.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
	NF Cable Cr	riparian planting-Tower fire recovery	1 mile	2003	USFS Umatilla NF	$600.00
	NF Cable Cr	riparian planting-Tower fire recovery	2 miles	2004	USFS Umatilla NF	$3,520.00
	NF Cable Cr	riparian planting-Tower fire recovery	1 mile	2005	USFS Umatilla NF	$13,900.00
	Lightning Cr	fish passage improvement	1 mile	2006	USFS Umatilla NF	$83,000.00
	Lightning Cr	riparian planting-Tower fire recovery	3 miles	2006	USFS Umatilla NF	$8,400.00
	Clear Cr	floodplain dredge tailings redistribution	.4 miles	2006	USFS Umatilla NF	$256,300.00
	Smith Cr	Riparian corridor fencing	.4 miles	2000	USFS Umatilla NF	$6,320.00
	Smith Cr	Riparian corridor fencing	.6 miles	1999	USFS Umatilla NF	$9,920.00
	Smith Cr	Riparian corridor fencing	.5 miles	1998	USFS Umatilla NF	$7,600.00
	Park Cr	Riparian corridor fencing	.3 miles	1997	USFS Umatilla NF	$2,080.00
	Camp Cr	Riparian corridor fencing	5.4 miles	1999	USFS Umatilla NF	$43,200.00
	Dry Camas Cr	Riparian corridor fencing	1 mile	1997	USFS Umatilla NF	$16,000.00
	Bear Wallow	Riparian corridor fencing	1 mile	1997	USFS Umatilla NF	$16,000.00
	Owens Cr	Riparian corridor fencing	.5 miles	2000	USFS Umatilla NF	$8,000.00
	Texas Bar Cr	Riparian corridor fencing	1.3 miles	1997	USFS Umatilla NF	$10,200.00
	Lane Cr	Riparian corridor fencing	3.5 miles	2001	USFS Umatilla NF	$28,000.00
	Kelsay Cr	Riparian corridor fencing	.6 miles	2003	USFS Umatilla NF	$9,600.00
	W.F. Meadowbrook Cr	Riparian corridor fencing	.5 miles	2002	USFS Umatilla NF	$8,640.00
	Smith Cr	Riparian corridor fencing	.6 miles	2002	USFS Umatilla NF	$8,960.00
	S. F. Big Wall	fish passage improvement	3 miles	1995	USFS Umatilla NF	$1,000.00
	Keating Cr	fish passage improvement	5 miles	1995	USFS Umatilla NF	$2,000.00
	E. F. Keating Creek	Channel restoration	.1 miles	1996	USFS \Umatilla NF	$4,500.00
	Ditch Creek	Riparian planting	4 miles	1998	USFS Umatilla NF	$4,000.00
	Wilson Creek	Riparian planting	5 miles	1997	USFS Umatilla NF	$3,000.00
	Indian Creek	large wood placement	4 miles	1997	USFS Umatilla NF	$8,600.00
	SF Big Wall Creek	fish passage improvement	4 miles	1998	USFS Umatilla NF	$2,000.00
	Oriental Creek	Oriental basin road obliteration	5.5 miles	1999	USFS Umatilla NF	$16,500.00
	Texas Bar Creek	Texas Bar basin road obliteration	4.2 miles	1999	USFS Umatilla NF	$12,600.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
	Wilson Creek	riparian corridor and pasture fencing	6.5	1996	USFS Umatilla NF	$52,000.00
	Bull Wilson Creek	riparian corridor and pasture fencing	3	2003	USFS Umatilla NF	$48,000.00
	Wall Creek	riparian corridor and pasture fencing	4.5	2003	USFS Umatilla NF	$36,000.00
	Colvin Creek - electric	riparian corridor and pasture fencing	1	1998	USFS Umatilla NF	$800.00
	Skookum Creek	riparian corridor and pasture fencing	2	1999	USFS Umatilla NF	$28,000.00
	Skookum Creek	riparian corridor and pasture fencing	4.5	2002	USFS Umatilla NF	$36,000.00
	Little Wall Creek	riparian corridor and pasture fencing	2	2004	USFS Umatilla NF	$28,000.00
	Bacon Creek	riparian corridor and pasture fencing	2.75	1997	USFS Umatilla NF	$22,000.00
	Little Wall Creek - electric	riparian corridor and pasture fencing	1.5	1998	USFS Umatilla NF	$1,500.00
	Three Trough Creek	riparian corridor and pasture fencing	1	1998	USFS Umatilla NF	$750.00
	Indian Creek	riparian corridor and pasture fencing	0.5	1996	USFS Umatilla NF	$4,000.00
	Indian Creek	riparian corridor and pasture fencing	2	1998	USFS Umatilla NF	$16,000.00
	Indian Creek	riparian corridor and pasture fencing	5.8	2004	USFS Umatilla NF	$46,400.00
	SF Big Wall Creek	riparian corridor and pasture fencing	3	1999-2000	USFS Umatilla NF	$42,000.00
	Dark Canyon	riparian corridor and pasture fencing	1.5	1999	USFS Umatilla NF	$12,000.00
	NFJD River multiple streams	Riparian Reforestation - conifers	22 acres	1995	USFS Umatilla NF	$11,000.00
	NFJD River multiple streams	Riparian Reforestation - conifers	21 acres	1996	USFS Umatilla NF	$10,500.00
	NFJD River multiple streams	Riparian Reforestation - conifers	23 acres	1997	USFS Umatilla NF	$11,500.00
	NFJD River multiple streams	Riparian Reforestation - conifers	60 acres	1998	USFS Umatilla NF	$30,000.00
	NFJD River multiple streams	Riparian Reforestation - conifers and hardwoods	54 acres	1999	USFS Umatilla NF	$32,400.00
	NFJD River multiple streams	Riparian Reforestation - conifers and hardwoods	93 acres	2000	USFS Umatilla NF	$55,800.00
	NFJD River multiple streams	Aspen Restoration	10 acres	1995	USFS Umatilla NF	$50,000.00
	NFJD River multiple streams	Aspen Restoration	20 acres	1996	USFS Umatilla NF	$100,000.00
	NFJD River multiple streams	Aspen Restoration	10 acres	1997	USFS Umatilla NF	$55,000.00
	NFJD River multiple streams	Aspen Restoration	12 acres	1998	USFS Umatilla NF	$66,000.00
	NFJD River multiple streams	Aspen Restoration	10 acres	1999	USFS Umatilla NF	$60,000.00
	NFJD River multiple streams	Aspen Restoration	10 acres	2000	USFS Umatilla NF	$60,000.00
	N. Fk. John Day	Buckaroo Flats riparian fencing	1 mile	2006	BLM	$11,000.00
	N. Fk. John Day	Wild and Scenic River Management	Camas Creek	2001	BLM	Unknown

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
		Plan changed season of use for grazing allotments to protect riparian conditions	to headwaters			
South Fork John Day Population						
20040814	South Fork John Day R	riparian fencing	0.33 m	1997	ODFW	$3,300.00
981088	South Fork John Day R	weirs, deflectors, streambank stabilization; off-channel livestock watering, stream crossings for cattle	3 crossings, 2 off-channel sites, 15 deflectors, 8 weirs	1999	Grant SWCD	$122,838.00
20040667	Rosebud Cr	riparian fencing, off channel watering, upland fencing	16 m rip fence, 2 sites, 10,032 ft upland fence	2004	Grant SWCD	$34,044.00
20040835	South Fork John Day R	riparian fencing	6.1 m	2001	ODFW	$1,250.00
20001166	South Fork John Day R	fish passage improvements: 1 push-up dam permanently removed	1	1999	Grant SWCD	$29,620.00
20050672		Upland vegetation management	3,711 ac weeds, 2,943 ac juniper	2005	Grant SWCD	$411,072.00
20050660	Bear Cr	Fish passage	1 culvert	2005	Grant SWCD	$19,337.00
20040817	South Fork John Day R	riparian fencing	0.33 m	1997	ODFW	$3,332.00
20010900	South Fork Murderers Cr	riparian fencing	1m	1999	ODFW	$10,000.00
20020595	South Fork John Day R	fish passage improvements: 1 push-up dam permanently removed and replaced with 1 permanent lay-flat stachion diversion structure	1	2000	Grant SWCD	$36,169.00
20010904	South Fork John Day R	riparian fencing	1m	2001	ODFW	$5,657.00
20001159	South Fork John Day R	bank stabilization with juniper riprap; riparian tree planting; fish passage improvements: 1 fish ladder installed, 1 push-up dam permanently removed, 1 fish screen installed on irrigation diversions	0.66 m juniper riprap, 1 dam, 3.5 ac planted	2000	Grant SWCD	$114,944.00
1174	South Fork John Day R	riparian tree planting	5 m, 24 ac	1997	Upper South Fork John Day Watershed Council	$6,082.00
20040832	South Fork John Day R	riparian fencing	0.5 m	1998	ODFW	$2,800.00
	Murderers Cr	Road Reconstruction and resurfacing (included 8 culvert upgrades and streambank bioengineering)	3.1 miles of stream	2001	USFS Malheur NF	$92,779.00
	NF Cable Creek	riparian planting-Tower fire recovery	1 mile	2003	Umatilla NF	$600.00
		riparian planting-Tower fire recovery	2 miles	2004	Umatilla NF	$3,520.00
		riparian planting-Tower fire recovery	1 mile	2005	Umatilla NF	$13,900.00
	Lightning	fish passage improvement	1 mile	2006	Umatilla NF	$83,000.00
		riparian planting-Tower fire recovery	3 miles	2006	Umatilla NF	$8,400.00
	Clear Creek	floodplain dredge tailings redistribution	.4 miles	2006	Umatilla NF	$256,300.00
	S. Fk. John Day	South Fork road repair to reduce erosion	.75 mile in two segments	2005	BLM	$144,000.00
	Indian Creek	Riparian fence	3 miles	2000	BLM	$6,000.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
	Soda Creek	Riparian fence	2 miles	2006	BLM	$8,000.00
	S. Fk. John Day	Wild and Scenic River Management Plan changed season of use for grazing allotments to protect riparian conditions	Smokey Ck. to Malheur NF boundary	2001	BLM	Unknown
Umatilla River Population						
20030716	Iskuulpa Cr (Squaw Cr)	Instream, riparian, road, upland (grazing, fencing, off-channel watering)	66 structures, 151 logs, 0.3 m rip planting, 25 off-channel sites, 20,000 ac exclusive, 11,612 ac rotation	2003	Confederated Tribes of the Umatilla Indian Reservation	$462,094.00
20030901	Little Butter Cr	Off-channel watering site	2 sites	2003	Morrow SWCD	$19,502.00
20050604	Meacham Cr	Upland vegetation management	3 ac	2004	Umatilla SWCD	$1,433.00
20050603	South Patawa	Upland vegetation management	45 ac	2005	Umatilla SWCD	$16,011.00
20030899		Off-channel	1 site	2003	Morrow SWCD	$10,861.00
20020641	Sandhollow Cr	off-channel livestock watering	2 sites	2002	Morrow SWCD	$4,946.00
20030742		Upland irrigation improvement	31 ac	2003	Hermiston Irrigation District	$6,170.00
20030903		Upland sprinklers	41 ac	2003	Morrow SWCD	$72,210.00
20030905	Stewart Cr	Fish passage	2 culverts	2003	ODOT	$300,000.00
20001200	Butter Cr	riparian fencing; off-channel livestock watering	0.63 m fenced, 1 site	1999	Umatilla SWCD	$9,823.00
20050602	Butter Cr	Upland vegetation management	22 ac	2004	Umatilla SWCD	$7,853.00
20001168	Little Butter Cr	instream habitat enhancement: anchored structures	0.25 m	1999	Morrow County Public Works	$37,785.00
20050606	Camas Cr	Upland vegetation management	6 ac	2003	Umatilla SWCD	$2,273.00
20020633	Butter Cr	riparian fencing; off-channel livestock watering	3.64 m, 20 sites	2002	Umatilla County SWCD	$122,069.00
20050718		Off-channel watering sites	3	2005	Morrow SWCD	$5,921.00
20050719		Off-channel watering site	1	2005	Morrow SWCD	$7,350.00
20030906	Stanfield Canal	Upland fenced, improved	20 ac	2003	Umatilla SWCD	$9,765.00
20030967	Webb Slough	Riparian fenced, off-channel	0.45 m, 2 sites	2003	Umatilla SWCD	$34,886.00
990730	Butter Cr	bank stabilization	0.06 m	1999	Umatilla SWCD	$6,535.00
20050617	Birch Cr, Bear Cr, West Birch Cr	Upland vegetation management	72 ac	2005	Umatilla SWCD	$36,822.00
20050616	Upper Butter Cr		107 ac	2005	Umatilla SWCD	$24,211.00
20050615	Stage Gulch		20 ac	2005	Umatilla SWCD	$218,917.00
990733		erosion control: grass seeding	23,650 ac treated	1999	Umatilla SWCD	$216,785.00
990732	Butter Cr	livestock exclusion, livestock grazing management plan	5,808 ft fence	1999	Umatilla SWCD	$5,016.00
990731	Butter Cr	bank stabilization	0.01 m	1999	Umatilla SWCD	$4,544.00
990729	Westgate Canyon Cr	weirs, cross berm creation; riparian tree planting	10 weirs, 1.7 m riparian planting, 1 m treated	1999	ODFW	$57,878.00
990728	Birch Cr	anchored structures, weirs, deflectors, channel alteration, cross berm creation; riparian tree planting, riparian fencing	105 anchors, 1 weir, 17 deflectors, 0.66 m fenced, 1,675 ft channel, 2.77m	1999	ODFW	$208,329.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
			riparian plant			
990727	East Birch Cr	anchored structures, weirs, deflectors, off-channel habitat (pond created), channel alteration, streambank stabilization, cross berm creation; riparian tree planting, riparian fencing	105 anchors, 10 weir, 39 deflectors, 1 pond, 12 ac treated, 1 m fenced, 7.5 ac riparian plant	1999	ODFW	$219,832.00
990726	Umatilla R	anchored structures, deflectors, bank stabilization; riparian tree planting, bio-engineering	52 anchors, 10 deflectors, 0.07 m stabilized, 0.38 m riparian plant, 2 ac treated	1998	ODFW	$122,144.00
20040735	Butter Cr	Upland fencing, off-channel watering site	7,497 m, 12 sites	2004	Umatilla SWCD	$112,507.00
20020709	Umatilla R	off-channel livestock watering	1	2003	Morrow SWCD	$11,071.00
20050607	McKay Cr	Upland vegetation management	22 ac	2005	Umatilla SWCD	$1,863.00
20050611	South Patawa	Upland vegetation management	3 ac	2005	Umatilla SWCD	$2,033.00
20040734	Butter Cr	Riparian fence, upland fence, of-channel watering site	0.19 m riparian, 21,650 ft upland, 12 sites	2004	Umatilla SWCD	$46,990.00
20050608	Twomile Cr	Upland vegetation management	2 ac	2003	Umatilla SWCD	$1,284.00
20050609	Rail Cr	Upland vegetation management	59 ac	2003	Umatilla SWCD	$16,773.00
20050610	Butcher Cr	Upland vegetation management	60 ac	2003	Umatilla SWCD	$15,531.00
	Little McKay	Fish habitat restoration	2 mi	2000-2003	USFS Ochoco NF	$200,000.00
		Culverts replaced for flow and fish passage	4	2005-2006	USFS Ochoco NF	$320,000.00
	McKay Creek	RHCA vegetation restoration along dispersed camping areas	4 mi	2005-2006	USFS Ochoco NF	$30,000.00
Walla Walla River Population (Oregon)						
20030800	Richartz Irrigation Ditch	Upland vegetation management	918 ac	2003	Walla Walla Basin Watershed Council	$370,205.00
20011007	Walla Walla R	Riparian tree planting	1 m, 15 ac	2001	Walla Walla Basin Watershed Council	$0.00
20050711	Walla Walla R	Upland irrigation	205 ac	2005	Walla Walla Basin Watershed Council	$1,723,311.00
20011006	Walla Walla R	fish passage improvements: 1 fish ladder installed	1	2001	Walla Walla Basin Watershed Council	$5,264,000.00
1127	Couse Cr	instream habitat enhancement: anchored log structures, deflectors; riparian planting & fencing; upland weed control	0.4 m fenced, 10.7 ac treated, 4 deflectors, 3 anchors	1997	Walla Walla Basin Watershed Council	$17,540.00
20030795	Walla Walla R	Upland	80 ac	2003	Walla Walla Basin Watershed Council	$3,848.00
20030796	Walla Walla R	Fish passage push-up dam, irrigation diversion, upland	1 dam, 1 diversion, 446	2002	Walla Walla Basin	$810,789.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
			ac upland		Watershed Council	
20011005	Walla Walla R	Instream water rights; irrigation systems for improved water conservation: sprinkler irrigation, 1 pond for storage, piping of delivery ditch	90 ac improved	2001	Walla Walla Basin Watershed Council	$68,007.00
20030798	South Fork Walla Walla	Upland	24 ac	2003	Walla Walla Basin Watershed Council	$50,966.00
20050618	Big Rayborn Canyon	Upland vegetation management	14 ac	2005	Umatilla SWCD	$5,816.00
991007	Cottonwood Cr & Little Meadows Cr	Surface drainage improvements, fence construction, rolling dip construction	8 culverts, 5 structures, 45 structures, 180 stations	1999	Walla Walla Basin Watershed Council	$143,028.00
20050614	Pine Cr	Upland vegetation management	21 ac	2005	Umatilla SWCD	$6,747.00
20030801	Powell Ditch	Upland vegetation management	17 ac	2003	Walla Walla River Irrigation District	$8,069.00
20040807	Hodgson, Rayborn & Dry Creek Canyons	Upland erosion control	4 ponds	2004	Walla Walla Basin Watershed Council	$54,287.00
20011004	North Fork Walla Walla R, South Fork Walla Walla R	Instream water rights; irrigation systems for improved water conservation; fish passage improvements: 3 push-up dams removed, replaced with 1 headgate, 1 consolidated w/other ditch, 1abandoned, 5 fish screens installed	572 ac	2001	Walla Walla Basin Watershed Council	$58,818.00
20050671	Rayborn Canyon	Upland vegetation management	7 ac	2005	Umatilla SWCD	$5,408.00
20030797	Walla Walla R	Fish passage, push-up dam, instream, upland	1 dam 1 ac	2003	Walla Walla Basin Watershed Council	$9,610.00
20050600	Rayborn Canyon	Upland vegetation management	12 ac	2004	Umatilla SWCD	$5,795.00
20030974	Ford Branch, Little Walla Walla R	Upland irrigation	18 ac	2003	Davis Orchards	$10,248.00
20050612	Couse Cr	Upland vegetation management	29 ac	2004	Umatilla SWCD	$10,553.00
20030794	Ford Branch	Upland		2003	Lefore Fruit Farms, Inc.	$7,207.00
20050601	Hay Cr	Upland vegetation management	31 ac	2004	Umatilla SWCD	$11,873.00
20050713	Little Walla Walla R	Upland irrigation improvement	9.7 ac	2005	Walla Walla Basin Watershed Council	$12,674.00
20040733	Spring Cr	Upland fence	10 ac	2004	Umatilla SWCD	$5,489.00
20001194	various	peak flow passage improvements, surface drainage improvements, road vacated, road closure, road grass seeded	2 structures, 4 corss-drains, 80 stations	2000	ODF	$57,294.00
20050709	North & South Forks of Walla Walla R	Upland vegetation management	140 ac	2005	Walla Walla Basin Watershed Council	$10,584.00
20020831	Walla Walla R	irrigation systems for improved water conservation	Water storage reservoir	2002	Walla Walla Basin	$19,260.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
					Watershed Council	
20050605	Pine Cr	Upland vegetation management	31 ac	2004	Umatilla SWCD	$9,374.00
20020632	Huffman Irrigation Ditch	irrigation systems for improved water conservation	475 ac	2002	Walla Walla Basin Watershed Council	$137,966.00
991048	Couse Cr	instream water rights transfers/leases		1997	Oregon Water Trust	$21,318.00
	S. Fk. Walla Walla	Moved campsites and traffic away from river and bridge replacement	0.5 miles	1998	BLM	$250,000.00
	N. Fk. Walla Walla	Riparian exclosure fence	0.5 miles	2005	BLM	$5,000.00
	SF Walla Walla	Push-up dam to be converted to pump	1	2003	OWEB	$4,000.00
	SF Walla Walla	Push-up dam conversion to rock weir	1	2003	CRITFC, OWEB	$16,000.00
	SF Walla Walla	Diversion and push-up dam not utilized/easement pending	1	2000	OWEB	$4,000.00
	NF Walla Walla	Diversion modified to eliminate need for push-up dam	1	2001	OWEB	$700.00
	NF Walla Walla	Eliminated push-up dam by consolidating to NF-8	1	2001	OWEB	$5,100.00
	NF Walla Walla	Push-up dam conversion to rock weir	1	2003	CRITFC OWEB	$12,000.00 $2,000.00
	Couse Cr	Instream lease of water (pump inactive)		1998	OWEB OR Water Trust	$36,780.00 $39,125.00
	Mainstem: Milton-Freewater to headwaters	Lockable headgate and water-measuring device	16 sites	2002	OWEB	$32,000.00
	Mainstem: Milton-Freewater to state line	Little Walla Walla push-up dam replaced with dam and fishway	1	2000	BPA	
	Smith Ditch	Ditch users have been consolidated to other sources		2002	OWEB OWEB pending Landowners	$15,000.00 $2,700.00 $15,000.00
	Nursery pump	Push-up diversion dam eliminated through consolidation to Eastside Diversion	1	2002	OWEB	$11,500.00
	Nursery Bridge Fishway	Fishway installed to allow passage past grade control structure	1	2001	BPA/COE	~$5,000.00
	Mainstem: Milton-Freewater to state line RM 42.5-44	Ditch piping, farm efficiency upgrades	1.5 miles	2000-2003	Landowners BPA OWEB WW River ID Hudson Bay ID OR Water Trust	$234,000.00 $478,000.00 $533,000.00 $46,000.00 $249,000.00
	Mainstem Walla Walla R., Mill Cr, NF WW R., SF WW R.	Ditch diversion, fish screen placement	29 diversions		ODFW, OWEB, BPA	
	Nursery Bridge	Fish screen placement		2000	ODFW Mitchell Act/ BPA	$80,000.00
	NF Walla Walla R., SF Walla Walla R.	Fish screen placement	5 sites	2001	OWEB	$175,000.00
		Fish screen placement (includes portables on the Smith ditch)	19 sites		ODFW Mitchell Act	$198,374.00
	Mill Cr (city screen)	Fish screen placement	1	2001	OWEB City of Walla Walla	$75,000.00 $135,000.00

Habitat Restoration Projects in Oregon Mid-Columbia steelhead population areas from 1995 through 2005 (OWEB 2006)						
OWEB Project Number	Stream Name	Project Description	Quantity	Year	Project Leader	Total Cost
					BPA	$210,000.00
	Walla Walla	Marie Dorian Dam removal	1	1997	CTUIR	
	Walla Walla	Little Walla Walla passage/screens	1	2000	CTUIR	$1,000,000
	Mill Creek	City of Walla Walla Intake Screens	1	2001	ODFW	$420,000.00
	North Fork, South Fork, mainstem Walla Walla	gravity ditch diversions screened	22	2000	ODFW	$246,058.00
	Walla Walla River	Eastside Ditch Screen	1	2001	ODFW	$80,000.00
	Walla Walla River	Riparian Easement	1500 feet	2003	CTUIR	
	South Fk Walla Walla River	Riparian Easement	3200 feet	2003	CTUIR	
	Walla Walla Subbasin	Upland Restoration	7737 acres	1998-2003	NRCS	
	Walla Walla River	Annual in-stream water lease	7.9 cfs	2003-2005	OR Water Trust	
	Couse Creek	Upland restoration and riparian fence	1.2 miles	2000	CTUIR	
	Walla Walla River	river flow restored in summer	25 cfs	2001-2005	USFWS	
	Walla Walla River	Riparian Easement	1900 feet	2001	CTUIR	
	Walla Walla Subbasin	CRP	18225	1998-2003	NRCS	
	Walla Walla Subbasin	CCRP	247	1998-2003	NRCS	
	South Fork Walla Walla River	Area of Critical Environmental Concern – protected management	1280 acres along 2.376 stream miles	1995-2005	BLM	
	South Fork Walla Walla River	Protected management, no roads, no logging	13708 acres	1995-2005	USFS	
	Mill Creek	Protected management, no roads, no logging in municipal watershed	5000 acres	1995-2005	USFS	
	Walla Walla Subbasin	Direct seeding sediment reduction on steep slope wheat farms	2812 acres	1998-2003	NRCS	
	Couse Creek	Riparian fence	1.3 miles	1997	CTUIR	
	Pine Creek	Riparian fence	1.5 miles	1999	SWCD	
	Dry Creek	Riparian Fence	.3 miles	1998	WWBWC	

APPENDIX D

Hydropower Configuration and Operational Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations

and

Estuary Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations

Hydropower Configuration and Operational Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations:

- Bonneville Powerhouse I (PH1) minimum-gap turbine runner (MGR) installations
- Bonneville PH1 juvenile bypass system (JBS) screen removal
- Bonneville PH2 corner collector installation
- Bonneville PH2 fish guidance efficiency (FGE) improvements
- Bonneville PH2 operation as first priority
- Bonneville spill operation improvements including five additional flow deflectors
- The Dalles spill wall construction
- The Dalles spill pattern improvements
- The Dalles sluiceway operation improvements
- The Dalles adult collection channel improvements
- John Day spill operation improvements
- John Day South Fish Ladder improvements
- McNary spill operation improvements
- McNary end spillbay deflectors and hoists
- McNary full flow juvenile passive integrated transponder (PIT)-tag detections
- McNary juvenile transport facility bypass piping improvements
- McNary spare extended-length submerged base screen
- McNary improved juvenile bypass dewatering screens
- McNary adult PIT-tag detection in fish ladders
- McNary overhauling auxiliary water supply (AWS) pumps
- McNary upgrading of adult fish ladders tilting weir controls

Estuary Improvements Implemented in Recent Years that Provide Survival Benefits to Oregon's Mid-C Steelhead Populations:

- Replaced three culverts with full-spanning bridges
- Provided approximately 10 miles of improved tidal channel connectivity by installing a tide gate retrofit
- Acquired approximately 473 acres of off-channel and riparian habitats
- Restored and created 90 acres of marsh and tidal sloughs and approximately 100 acres of riparian forests
- Protected approximately 55 acres of high quality riparian and floodplain habitat
- Restored and preserved approximately 154 acres of off-channel habitat
- Protected 80 acres of high-value off-channel forested wetland habitat
- Restored approximately 96 acres of tidal wetlands habitat by replacing undersized culvert that limited fish access
- Conserved 155 acres of forested riparian and upland habitat
- Provided partial tidal channel reconnection by tide gate retrofit (acreage unknown at this time)
- Provided integrated pest management (purple loosestrife)
- Reconnected and restored 183 acres of historical floodplain by dike removal
- Restored 25 acres of historical floodplain by breaching a dike

APPENDIX E

U.S. Forest Service
Bureau of Land Management

Forest Service and Bureau of Land Management Programs in Support of Mid-Columbia Steelhead Recovery Sufficiency Assessment

Forest Service and Bureau of Land Management Programs in Support of Mid-Columbia Steelhead Recovery Sufficiency Assessment

May, 2007

Executive Summary

The Forest Service (FS) and Bureau of Land Management (BLM) have in place a *Management and Conservation Framework* that is comprised of programs that contribute to recovery of ESA-listed salmon and steelhead on federal lands, these include:

1. A diverse body of environmental laws and regulations
2. Agency policies
3. Land Management Plans with associated aquatic strategies, and
4. Guidance and procedures for project design, implementation, and monitoring

Collectively, this existing *Management and Conservation Framework* represents the "baseline" that governs land management, contributing to both short and long-term recovery goals for ESA-listed salmon and steelhead on federal lands. While elements of the framework may be revised or amended over time, the interwoven nature of statutes, regulations and policies, as well as interagency and public processes, maintains the integrity and overall effectiveness of the framework in providing meaningful contributions to salmon and steelhead recovery.

The foundation of the Management and Conservation Framework are two aquatic strategies known as (PACFISH and the Northwest Forest Plan – Aquatic Conservation Strategy (NWFP-ACS). PACFISH was incorporated into FS and BLM Land Management Plans in 1995 and the NWFP ACS amended Forest Service plans on the east slope of the Cascade mountain range in 1994. These aquatic strategies provide for the long-term protection and appropriate management of physical or biological features essential to recovery of ESA-listed salmon and steelhead on federal lands.

Forest Service and BLM Aquatic & Riparian Habitat Management and Conservation Framework

Introduction

The Forest Service (FS) and Bureau of Land Management (BLM) have in place a *Management and Conservation Framework* that is comprised of programs that contribute to recovery of ESA-listed steelhead on federal lands. These include:

1. A diverse body of environmental laws and regulations; for example, the Clean Water and Endangered Species Acts;
2. Agency policies
3. Land Management Plans with associated aquatic strategies, and
4. Guidance and procedures for project design, implementation, and monitoring

Collectively, this existing *Management and Conservation Framework* represents the "baseline" that governs land management, contributing to both short and long-term recovery goals for ESA-listed steelhead on federal lands. While elements of the framework may be revised or amended over time (e.g., Congress may pass new statutes, agencies may revise plans, etc.), the interwoven nature of statutes, regulations, and policies – as well as interagency and public processes – maintains the integrity and overall effectiveness of the framework in providing meaningful contributions to salmon and steelhead recovery.

The following describes the primary building blocks in the *Management and Conservation Framework* the Forest Service (FS) and Bureau of Land Management (BLM) apply to federally-managed lands within the Pacific Northwest (States of Idaho, Oregon, and Washington) that contribute to salmon and steelhead recovery goals and objectives, and guide recovery actions:

Land Management Plans

FS and BLM *Land Management Plans* contribute to recovery by providing assurances that public lands are managed in accordance with Federal Land Policy and Management Act of 1976 (43 U.S.C. 1701 *et seq.*)/(FLPMA), the National Forest Management Act/(NFMA) of 1986, and other applicable laws, regulations and policy. These legal and policy requirements ensure the federal land managing agencies make informed decisions and provide for the responsible management of public land resources, including ESA-listed species.

Both FS and BLM *Land Management Plans* describe broad, multiple-use guidance for managing public lands and mineral estates. Plan decisions are made at a broad scale and guide site-specific project design and approval. *Land Management Plans* highlight goals and objectives for resource management and establish management guidance needed to achieve them. Plans also identify what public and commercial uses are appropriate and where they should occur. Land *Management Plans* contain protective management direction, in some cases even stronger than PACFISH or the NWFP-ACS. Applicable to specific large blocks of land, these additional protections include; Congressionally designated Wilderness, Wild and Scenic Rivers and municipal watersheds. In addition, some types of management areas also receive strong watershed-scale protections based on land use decisions contained in land management plans. Examples include; allocations and management direction for non-motorized dispersed recreation areas, and Scenic Areas. All *Land Management Plans* are developed with public involvement,

and impacts of a plan are analyzed in an appropriate NEPA document. Plans also contain a monitoring component to provide continuous feedback on the efficacy of direction in meeting {plan} objectives.

Within the range of Columbia and Snake River basins, the FS and BLM rely on these two aquatic strategies, PACFISH and the NW Forest Plan – ACS, to ensure that actions on federal lands prevent further degradation and begin to restore high quality in-stream and riparian habitat conditions in support recovery of ESA-listed salmon and steelhead. Current FS and BLM *Land Management Plans* west of the Cascades in Oregon and Washington were amended by the NWFS EIS Record of Decision (ROD) in 1994, amended in 2003. East of the Cascades (eastern OR/WA, ID) were amended by a PACFISH Decision Notice in 1995

PACFISH and the NWFP-ACS are described individually in more detail below:

PACFISH

(Aquatic Strategy for Managing National Forest System and Bureau of Land Management Anadromous Fish Producing Watersheds in Eastern Oregon, Washington, Idaho, and portions of northern California)

In February, 1995, Forest Service (FS) and Bureau of Land Management (BLM) administrative units with anadromous fish, outside the range of the northern spotted owl covered by the Northwest Forest Plan – Aquatic Conservation Strategy (NWFP-ACS) in Oregon, modified their *Land Management Plans* through amendment by PACFISH. PACFISH was developed as an ecosystem-based, interim strategy designed to arrest the degradation of habitat and begin restoration of in-stream and riparian habitats on lands administered by the FS and BLM in eastern Oregon and Washington, Idaho, and portions of northern California. The intent of the strategy was to allow for 'passive' restoration of the ecological health and productivity of watersheds that contain present or potential anadromous fish habitat through the application of riparian standards and guidelines to both proposed and ongoing actions. PACFISH was to remain in place until longer term aquatic conservation strategies, similar to the NWFP-ACS were completed through *Land Management Plan* amendment or revisions (PACFISH Environmental Assessment, 1994). Those revisions have not yet occurred, and PACFISH still applies wherever NWFP-ACS does not already apply.

PACFISH contains the following components that are applied to FS and BLM management actions to maintain and restore ecological processes that support high quality habitat for salmon and steelhead:

- Riparian Goals – *establishes an expectation of the characteristics of healthy, functioning watershed, riparian areas, and associated fish habitats;*
- Riparian Management Objectives (RMOs)- quantitative *RMOs for stream channel, riparian and watershed conditions were developed to provide the criteria against which attainment or progress toward attainment of the riparian goals are measured. RMOs provide measurable targets toward which managers are aiming as they conduct resource management activities across the landscape. The objectives are time specific to reflect the ecological capabilities of specific ecosystems;*

- Delineation of streamside areas (Riparian Habitat Conservation Areas, aka "RHCA"s) that are important to maintenance of high quality aquatic habitat and where special management considerations are applied - *PACFISH requires that proposed actions within RHCAs do not prevent or retard attainment of RMOs. RHCAs include traditional riparian corridors, wetlands, intermittent streams, and other areas that help maintain the integrity of aquatic ecosystems by (1) influencing the delivery of coarse sediment, organic matter, and woody debris to streams, (2) providing root strength for channel stability, (3) shading the stream, and (4) protecting water quality;. RHCA widths vary depending upon the aquatic and riparian resources to be protected in each stream reach, based on stream and riparian characteristics.*
- Standards and/or guidelines *to ensure to the extent legally possible, that projects do not prevent or retard attainment of riparian goals and management objectives*;
- Designation of *Key* or *Priority* watersheds - *areas where additional management emphasis and/or watershed analysis is required to ensure that salmon and steelhead habitat is maintained or provided priority for restoration*;
- Watershed analyses - *to provide sufficient context for designing actions that support maintenance or restoration of aquatic habitats needed for recovery of ESA-listed salmon and steelhead* ;
- Watershed restoration efforts focused through watershed analysis;
- Monitoring program to evaluate project implementation (compliance) and effectiveness of PACFISH as a strategy for protecting and improving aquatic habitat conditions on federal lands. http://www.fs.fed.us/rm/boise/research/techtrans/projects/pacfish_home.shtml

PACFISH, combined with underlying Land Management Plans and *BLM* Rangeland Health Standards, and complemented by consultation programs conducted for compliance with the Endangered Species Act, provides the program guidance needed to protect and conserve steelhead and their habitat on federal lands. The protective guidance provided by these programs is applied on every FS and BLM project during project development and implementation. They have been determined to be sufficient in terms of their intended purpose of protecting habitat for ESA-listed salmon and steelhead to the extent permitted by law, thereby promoting recovery of the species and their habitats.

PACFISH provides a framework for minimizing adverse effects from land management activities on aquatic resources through the assessment of proposed or ongoing management actions, within RHCAs, with Riparian Goals and Riparian Management Objectives (RMOs). Standards and Guidelines are applied to actions within Riparian Habitat Conservation Areas (RHCAs) to ensure that they do not prevent or retard attainment of high quality aquatic habitat (RMOs). The use of Watershed Analysis and special considerations provided in *KEY* watersheds (priority populations) provide another level of management consideration that increases certainty of outcomes for protection and meeting of both short and long-term recovery goals.

Preliminary results from broad-scale aquatic habitat status and trend monitoring of FS and BLM lands within the interior Columbia River basin since 2001 indicates conditions have improved over the past 5 years, continuing the habitat recovery presumed to have begun in 1995 as a result of the protections PACFISH instituted. Implementation and Effectiveness Monitoring will both

continue to evaluate the overall long-term effectiveness of PACFISH policy and program directives at preventing further degradation of habitat for native anadromous and resident salmonids, and its effectiveness at restoring near-natural rates of habitat and species recovery on actively managed FS and BLM lands, particularly within streamside riparian areas on streams affected by ongoing livestock grazing.

Northwest Forest Plan's Aquatic Conservation Strategy and Protective Land Allocations In Oregon and Washington

The Northwest Forest Plan ACS (NWFP-ACS) was designed to incorporate all elements of an aquatic and riparian ecosystem necessary to maintain its natural disturbance regime. The NWFP-ACS applies to all FS and BLM lands within western WA, OR, and the east face of the Cascades in WA.

Aquatic ecosystem elements embedded in the NWFP-ACS include; maintenance of hydrologic function, high water quality, adequate amounts of coarse woody debris, complex stream channels that provide a diversity of aquatic habitat types, and riparian areas with suitable microclimate and vegetation. These elements directly or indirectly correspond to each of the physical and biological attributes of 'Primary Constituent Elements' identified as characterizing salmon and steelhead designated critical habitat: water quality and quantity; substrates; shade; large wood; cover; conditions suitable for forage production; channel form and connectivity with floodplains; and, unobstructed migration corridors. Since being amended to FS *Land Management Plans* in the eastern Cascades in 1994, the NWFP-ACS has created a connected system of aquatic and riparian habitats throughout the plan area that are assumed to be reversing the trend of aquatic and riparian habitat degradation and begun the long recovery process for these habitats over the past 12 years.

Most primary program components of the NWFP-ACS are similar to those found in PACFISH. NWFP-ACS components include:

- Aquatic Goals and Objectives - *each project must maintain or restore the physical and biological processes required by riparian dependent-resources at the watershed scale or broader to comply with the ACS*
- Riparian Reserves - *portions of watersheds where riparian-dependent resources receive primary emphasis. The extensive Riparian Reserves within the Northwest Forest Plan area protect the stream and adjacent riparian areas critical to maintaining a highly functioning aquatic ecosystem,*
- Standards and Guidelines – *Standards and Guidelines prohibit and regulate activities in Riparian Reserves that retard or prevent attainment of the ACS aquatic/riparian objectives. Use of these provides assurances that a project cannot have a negative impact in the long- term on riparian-dependent resources or ecological processes in the Riparian Reserves at the watershed scale.*
- Key Watershed network *-serves as refugia for anadromous salmonids,*
- Watershed analyses - *to provide sufficient context for designing actions that support maintenance or restoration of aquatic habitats needed for recovery of ESA-listed salmon and steelhead* ;

- Watershed Restoration Strategy-*a formal restoration strategy based on watershed analysis.*
- Monitoring-*a formal long-term broad-scale monitoring program*
- Adaptive Management-*ongoing adjustments in management based on monitoring and other new information as it becomes available.*

Riparian Reserves
The NWFP-ACS provides the foundation for the conservation and recovery of anadromous fish species on federally-managed lands through use of Riparian Reserves. Riparian Reserves are portions of watersheds where riparian-dependent resources receive primary emphasis. In conjunction with the Key Watershed network, these areas serve as refugia for ESA-listed and non-listed anadromous fish.

Land Allocations
The NWFP-ACS, with additional protective land allocations, collectively provides an extensive network of Riparian Reserves and watersheds contributing to the protection and restoration of aquatic ecosystems on federally-managed lands.

Large proportions of federal lands within the NWFP area in Oregon are in some form of *Reserve* or *Special Management* status. *Reserve* or *Special Management* status lands are those where land management actions are largely prohibited or significantly shaped by application of protective Standards and Guidelines (S&Gs) for land management activities. These specially-managed lands are located both within and outside Key Watersheds. Federal lands outside of Key Watersheds are also protected under other land allocations including; Riparian Reserves, Congressional Reserves such as Wild and Scenic River corridors, Wilderness and/or Municipal Watersheds; spotted owl Late-Successional Reserves (LSRs) and Areas Withdrawn from active management (Forest Service) through Forest Plans.

NWFP-ACS Standards and Guidelines are also required to be applied within LSRs, providing increased protection for all stream types. As LSRs have late-successional characteristics, and are overlain with Riparian Reserves, they serve as core areas of high quality stream habitat, fish refugia, and centers from which degraded aquatic systems can be recolonized once they are restored. Streams within these reserves may also be particularly important for endemic or locally distributed fish species and stocks. Collectively, these protective upland land allocations (non-Riparian Reserve; not located in Key Watersheds) comprise 1,331,636 acres or 17 percent of federally-managed lands within the area of designated critical habitat for anadromous fish in Oregon and Washington.

Watershed Analysis and Watershed Restoration
Watershed analysis, a requirement of the NWFP-ACS, provides an understanding of aquatic habitat conditions and processes. This informs land management decisions regarding the timing, location, and magnitude of activities on the landscape to protect and/or restore the physical and biological features essential to the conservation of anadromous fish. Watershed analysis also provides information on priorities for watershed restoration. The FS has made significant investments in watershed restoration in the NWFP area since its inception in 1994. Activities have emphasized; restoration of fish passage, reductions in the delivery of fine sediments to

stream channels, placement of large wood debris in stream channels, riparian plantings and thinning to accelerate large wood recruitment/increase shade/improve nutrient cycling, and have included control of noxious weeds, and obliteration or high-level maintenance of as risks to meeting aquatic habitat objectives

Monitoring
The NWFP-ACS also contains a long-term monitoring component to evaluate progress towards goals for protection and management of physical and biological features essential to long-term conservation of ESA-listed salmon and steelhead. In the NWFP ACS, monitoring is considered an essential component of management as the information it provides helps to evaluate the overall success of the applied strategies and allows for needed adjustments. Four types of monitoring are conducted by the FS:

- *Implementation monitoring* - to determine if activities (i.e., timber sales, silvicultural projects, watershed restoration, etc.) were implemented as planned and whether or not they meet NWFP-ACS Standards and Guidelines.
- *Effectiveness monitoring* - evaluate if NWFP-ACS Standards and Guidelines are meeting the strategy's goals and objectives. www.reo.gov/monitoring/watershed.
- *Validation monitoring* is primarily research-oriented and directed at testing underlying assumptions upon which management strategies are based. http://www.reo.gov/monitoring/10yr-report/documents/synthesis-reports/all.pdf., http://ocid.nacse.org/nbii/density/pubs.html, http://www.fs.fed.us/pnw/publications/index.shtml
- *Local* - In addition, many of the local FS and BLM administrative units conduct annual monitoring (implementation, effectiveness) to address local management issues.

Adaptive Management

Adaptive Management is described in the Northwest Forest Plan (USDA and USDI 1994a) as a continuing process of action-based planning, monitoring, researching, evaluating and adjusting with the objective of improving the implementation and achieving the goals of the standards and guidelines. Using this process, new information is evaluated and then serves as the basis for decisions on needed adjustments to management. Adjustments may also result in the refinement of standards and guidelines, land-use allocations, or amendments to FS and BLM Land Management Plans.

Collectively, these NWFP-ACS program components emphasize aquatic habitat management for protection and recovery ESA-listed anadromous salmonid ESUs on NFS and BLM lands.

APPENDIX F

State of Oregon Programmatic Review

Statewide Habitat Programs Implemented by Oregon State Agencies to Address Limiting Factors and Threats to the Recovery of Listed Anadromous Salmon and Steelhead

Statewide Habitat Programs Implemented by Oregon State Agencies to Address Limiting Factors and Threats to the Recovery of Listed Anadromous Salmon and Steelhead

Table of Contents **Page**

Executive Summary……2
Introduction 4
Conceptual Framework 4
Program Review Process..... 8
Results.....9
Conclusions and Recommendations 10
Appendix 1. Program Descriptions..... 11
Appendix 2. Program Strategies and Land Use Jurisdictions..... 22
Appendix 3. Program Sufficiencies to Address Fine Sediment Impacts 25
Appendix 4. Program Sufficiencies to Address Habitat Complexity Impacts. 32
Appendix 5. Program Sufficiencies to Address Water Temperature Impacts. 37
Appendix 6. Program Sufficiencies to Address Fish Passage Impacts 43
Appendix 7. Program Sufficiencies to Address Instream Flow Impacts..... 47
Appendix 8. Program Sufficiencies to Address Agriculture and Forestry Chemical Impacts..... 51
Appendix 9. Program Sufficiencies to Address Animal Waste Impacts. 53
Appendix 10. Program Sufficiencies to Address Human, Urban, or Industrial Waste Impacts. . 54
Appendix 11. Addition Program Documentation. 55

Executive Summary

Natural resource agencies within the State of Oregon conducted an internal review of their habitat-based programs to assess sufficiency in addressing threats, and associated limiting factors, to the recovery of listed anadromous salmonids in Oregon. This assessment is a component of Oregon's recovery planning effort, specifically in guiding development of basin actions for specific populations. The process builds on the foundation of the Oregon Plan for Salmon and Watersheds wherein the collective and coordinated actions of natural resource agencies synergistically care for Oregon's watersheds and salmon.

Sufficiency of statewide programs was based on technical, institutional, budgetary, implementation, and documentation criteria, and categorized according to certainty, or lack thereof, of sufficiency in addressing limiting factors. Program jurisdiction on federal, state, and private forests, agricultural lands, and urban/rural residential lands was also identified. Factors limiting to salmonid viability were characterized as habitat access, food web dynamics, physical habitat quality and quantity, water quality, and water quantity and flow timing. Eight management strategies were identified for addressing limiting factors and threats related to freshwater habitat conditions.

(*Note: final sufficiency analysis is ongoing and incomplete*).

Key constraints to program effectiveness included inadequate outreach and education, monitoring, technical assistance, prioritization, and program oversight, all of which are a result of inadequate funding and staff resources. Monitoring of program actions on the ground was identified as being crucial to providing rigor and necessary documentation of program effectiveness and sufficiency.

Introduction

Oregon is in the process of developing recovery plans for salmon and steelhead populations in the state that are listed as threatened or endangered under the U.S. Endangered Species Act (ESA). One step in the development of these recovery plans is consideration of the ability of existing regulatory, management, or incentive-based programs to address the habitat factors that have historically limited, or are currently limiting, the salmon and steelhead populations in Oregon. This document provides information about limiting factors and critical "bottlenecks", and evaluates the likely influence the agency programs will have on addressing limiting factors and bottlenecks for improving habitat and population trends.

While completion of this document is not a federal ESA requirement, its contents will be included in recovery plans being developed across the state, and will serve as a resource for the planning teams tasked with developing specific action plans for each of the salmon and steelhead recovery planning domains in Oregon.

State regulatory and management mechanisms are important tools to preventing the continued decline of habitats and promoting their protection and restoration to create healthy watersheds for fish. Thus, in evaluating the various regulatory programs, the process considers the degree to which practices that were historically adverse have been stopped, the impact of the current standard to improve conditions over time, and the adequacy of companion non-regulatory programs to timely restore desired conditions. This process will also serve as a baseline from which improvement can be measured toward reducing threats that initially contributed to a listing decision. The listing (and delisting) decision includes as one criteria (among several) the "inadequacy of existing regulatory mechanisms" that threaten the continued existence of a species.

This process builds on the regulatory, incentive-based and management foundation established prior to and for the Oregon Plan for Salmon and Watersheds, wherein the collective and coordinated actions of natural resource agencies work to synergistically care for Oregon's watersheds and salmon. While agency programs in large part were not intended to achieve habitat conditions that foster recovery, they *were* intended to improve watershed conditions in general for salmon.

Conceptual Framework

Limiting factors are the physical, biological, or chemical conditions and associated ecological processes and interactions (e.g., population size, habitat connectivity, water quality, water quantity, streambank sloughing etc.) experienced by the fish that may influence viable salmonid population (VSP) parameters (i.e. abundance, productivity, spatial structure, and diversity). There are five broad categories of habitat limiting factors:

Water quantity/hydrograph –Magnitude and timing of flows.

Water quality – Water characteristics including temperature, dissolved oxygen, suspended sediment, pH, toxics, etc.

Food Web – The complex of interrelated food chains that ultimately feed salmon and steelhead.

Physical habitat quality/quantity – The amount and characteristics of physical habitat such as amount of large wood in the stream channel, occurrence of deep pools, and silt free spawning gravel.

Habitat access – Impaired access to spawning and/or rearing habitat.

As illustrated in Figure 1, many interrelations exist between the limiting factor categories. For example, a water quantity/hydrograph limitation can influence habitat access (dewatered stream channels), water quality (less dilution of pollutants), physical habitat quality (changing macro and micro habitat conditions), and food web (altering nutrient retention rates).

Threats are the human actions (e.g., fishing, operation of hatcheries, operation of the hydro system, road building, riparian habitat degradation, channel straightening, etc.) or natural occurrences (e.g., flood, drought, volcano, tsunami, etc.) that *cause or contribute-to* limiting factors and site-specific "bottlenecks".

Management strategies describe how recovery goals will be achieved by stating the general approaches that set the path from current conditions to the desired future state. Management strategies guide the creation of *management actions*, which are specific activities or behaviors intended to address the bottleneck to help achieve one or more recovery goals.

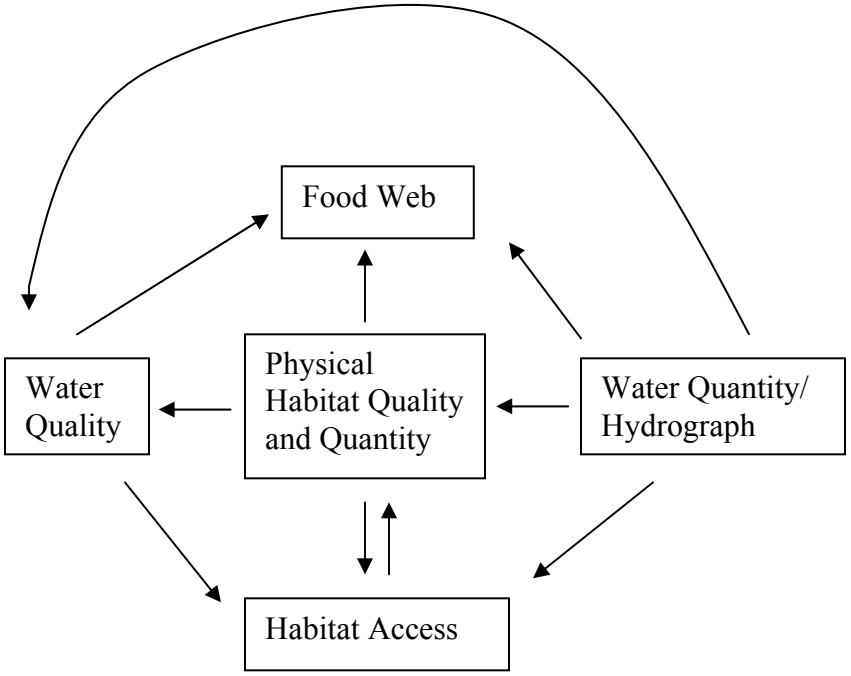


Figure 1. Interrelation between limiting factor categories.

Recovery planners have identified eight management strategies that are needed to address limiting factors (or bottlenecks) and threats related to freshwater habitat conditions. Table 1 shows these management strategies and the limiting factor categories they address as well as examples of threats that can lead to the limiting factor becoming a concern.

Although the management strategies provide a useful general approach and framework for recovery efforts, they do not necessarily provide the detail needed to assess if specific key limiting factors are adequately addressed by existing management programs. This review focuses on the adequacy of State of Oregon programs to impact the following specific key limiting factors common to all recovery planning domains in Oregon:

- Excessive fine sediment in spawning gravel
- Low habitat complexity
- High water temperature
- Impaired passage
- Inadequate stream flows or altered timing of flows
- Agricultural and forestry chemicals
- Animal waste
- Human, urban, or industrial waste

Table 1. Relationship between limiting factors, specific threats and management strategies addressed by statewide programs.

Management Strategies	Limiting Factors Addressed	Examples of Threats Addressed
1 - Protect and conserve ecological processes that support the viability of populations and their life history strategies throughout their life cycle.	All habitat limiting factors	See individual limiting factors.
2 – Restore and maintain floodplain connectivity and function	Habitat access, Food web, & Physical habitat quality	Stream straightening, channelization and diking, wetland draining and filling, dams that limit sediment movement
3 - Restore riparian condition and LWD recruitment, and maintain conditions adequate to support natural stream function and processes	Water Quality, Food web, & Physical habitat quality	Riparian habitat use and degradation, introduction of non-native plants that alter riparian function.
		Urban, residential or commercial development
		Stream cleaning and splash damming.
		Fine sediment from roads and other upland disturbances.
4 – Restore and maintain passage and connectivity to habitats blocked or impaired by artificial barriers	Habitat access	Dams, culberts, tidegates, road crossings, and hatchery weirs.
5 - Restore stream flows and natural hydrograph to provide sufficient flow during critical periods.	Water quantity/hydrograph & Habitat Access	Municipal and irrigation water withdrawals
		Urban, residential or commercial development
		Hydropower and flood control dams
		Riparian habitat use and degradation, introduction of non-native plants that alter riparian and upland functions.
6 - Restore and maintain channel structure and complexity.	Physical habitat quality & Food web	Riparian use and degradation, and introduction of non-native plants that alter riparian and upland functions.
		Stream cleaning, splash damming, straightening, channelization, and diking.
7 - Improve degraded water quality and maintain unimpaired water quality	Water quality	Municipal and irrigation water withdrawals
		Hydropower and flood control dams
		Agricultural, municipal, and industrial effluent and toxins.
		Fine sediment from roads, agricultural practices, development.
		Riparian habitat use and degradation, introduction of non-native plants that alter riparian and upland functions.
8 - Restore degraded upland processes to limit potential adverse impacts of uncharacteristic erosion and runoff, and maintain healthy upland processes.	Water & Physical habitat quality	Fine sediment from roads, agricultural practices, development.
		Urban, residential, or commercial development
		Riparian habitat use and degradation, introduction of non-native plants that alter upland functions.

Program Review Process

Program managers from each natural resource agency were asked to provide information on statewide programs currently implemented by their agencies that address the key limiting factors described earlier. Four categories of information regarding these programs were requested:

1) A general description of the program, including documentation of the program's guidance, jurisdiction, and implementation timeline. Appendix Table 1 lists this information for each program evaluated.
2) A list of the management strategies addressed by the program and the land use for which the program is intended. Appendix Table 2 lists this information for each program evaluated.
3) An evaluation of the program ("sufficiency") in the context of the key limiting factors (*ongoing)*, the rationale for the sufficiency characterization, recommendations for modification to the program to improve its sufficiency, and constraints on the program that may hamper its ability to fully address the key limiting factor. Varying levels of documentation is also provided that supports or addresses "sufficient" or "likely to be sufficient" assessments. Table 2 shows the criteria used to assess the programs. Appendices Tables 3-10 show this information by key limiting factor for each program.
4) A list of references that provide more detailed information about the program (see Appendix 11).

Table 2. Criteria used to determine sufficiency of programs to address key habitat limiting factors to the recovery of Oregon salmon and steelhead populations.

Sufficiency Designation	Criteria for Designation
Yes	Adequate technical, institutional, and budgetary capacity to implement the program, has a clear timeline for implementation, and documentation that the program can significantly reduce the limiting factor/threat within the program's jurisdictional area.
Likely	Adequate technical, institutional, and budgetary capacity to implement the program, has a clear timeline for implementation, and documentation that the program can significantly reduce the limiting factor/threat within the programs jurisdictional area, but it is a relatively new program with limited documentation on program effectiveness.
Uncertain	Adequate technical, institutional, and budgetary capacity to implement the program within its jurisdictional area, but the program lacks an adequate monitoring program, or has no clear timeline for implementation.
No	Inadequate technical, institutional, or budgetary capacity to implement the program within its jurisdictional area.

Program managers were asked to focus their efforts on "programs" that implement conservation, protection, or restoration actions. Programs whose sole function is monitoring the status and/or trend in natural resources are not included in this review.

Results

A total of 36 programs within nine natural resource agencies were evaluated (Table 3; Appendix Tables 1, 3-10). ODEQ had the most programs (7) addressing the most limiting factors (6), while ODLCD and ODOT had the fewest programs (1) addressing from 1-3 limiting factors.

Note: Sufficiency analysis is ongoing, therefore final results are not adequately complete for presentation in this report. Refer to Appendices for descriptive analysis of programs.

Agencies identified the need for adequate and dependable funding and increased staff resources to improve program sufficiency, especially those programs characterized as uncertain or insufficient. These limitations hamper or preclude sufficient outreach and education to landowners, effectiveness and compliance monitoring, technical assistance, program development, implementation, and oversight, and necessary inventories. Monitoring of program action effectiveness is crucial to understanding and acknowledging program sufficiency, and to adjusting program elements for improved adequacy. Trend monitoring is especially important to delineating progress or problems over time.

Jurisdictional limitations, overly broad statutory directives, increasing costs, and reliance on other state and local authorities for implementation constrain effectiveness of some programs. In addition, coordination and collaboration, both internally among state agencies and externally with federal land managers and private land owners, remains an important need to more fully address landscape issues. Some voluntary programs also conflict with landowner values and priorities, necessitating highly favorable incentives to overcome these social hurdles to effect positive change.

Conclusions and Recommendations

This review was conducted prior to specific benchmarks being established for recovery goals or an analysis of the predicted benefits of specific actions currently undertaken by each program, and programs combined. Nonetheless, using the detailed information provided in the Appendices on program objectives, jurisdiction, guidance, timelines, modifications and constraints should provide useful information for individual planning teams for each recovery domain as they formulate specific action plans for each ESA-listed salmon and steelhead population. This information will likely be helpful in the future as the state strives to improve its effectiveness in addressing habitat limiting factors.

Note: Sufficiency analysis of programs is incomplete.

Monitoring is especially critical to improving accountability, increasing knowledge of action effectiveness, and strengthening rigor in future assessments. An appropriate evaluation of a program's sufficiency requires field monitoring and documentation to assess whether program implementation on the ground is having the desired effect in addressing threats and limiting factors. For many programs, monitoring is absent or limited, tempering the ability to adequately evaluate its effectiveness. A number of program evaluations were based on the sufficiency and soundness of the infrastructure or process for implementing the program or an accounting of activities. To adequately assess action effectiveness and program sufficiency, actual monitoring and measurement of habitat conditions and trends must take place.

Continued emphasis on agency collaboration and coordination will strengthen the Oregon Plan foundation to better meet recovery needs now and into the future. The integrated workings and commitments of multitude agencies are needed to provide greater and more durable benefits to Oregon's salmon, watersheds, and citizens. Unfortunately, the relative contribution of these programs, in the context of overall importance to the landscape, was not assessed. Also not assessed was the cumulative and synergistic contribution of various programs to achieve overall habitat protection goals. This is an important consideration as no one program was intended to address any one limiting factor completely. *It is possible that individual programs by themselves are not adequate to address specific threats and limiting factors for meeting recovery goals, but the combined suite of available state agency programs in aggregate may create an adequate overall program for the state regarding a specific limiting factor.*

The collective efforts of state habitat programs has made comparative progress in improving trends over the past ten or more years, due in part to the Oregon Plan. The services these programs provide to the public and the regulatory oversight afforded are essential to maintaining a balance in protecting Oregon's natural resources within the context of resource use and development. However, improving landscape function to achieve recovery will require a concerted and conscious effort by many, including Oregon's natural resource agencies. Future funding packages to support and bolster programs to facilitate effectiveness would enhance this state's efforts toward recovery.

Appendix Table 1. Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODA	Agricultural Water Quality Management (SB 1010)	In 1993 the legislature established the Agricultural Water Quality Management Act. In 1995, the legislature supplemented the Act with ORS 561.191. This statute reinforces ODA's responsibility for and jurisdiction over agricultural practices and water pollution associated with activities on agricultural and rural lands. Administrative rules adopted to guide Program administration are found in OAR Chapter 603, Divisions 90 and 95. Regulatory actions address violations when they arise. Monitoring tools include DEQ ambient monitoring sites, local monitoring programs such as Rogue Valley Council of Government's Bear Creek monitoring and ODA Riparian Conditional Analysis for agricultural lands.	Ag Water Quality Mgmt Act	All agricultural practices and water pollution associated with activities on agricultural and rural lands, excluding federal or tribal trust lands.	Affected by rate of riparian vegetation development where needed. Development timeline will vary from 5 to 50 years depending on present site condition and site potential.
ODA	Confined Animal Feeding Operation (CAFO)	Confined Animal Feeding Operation (CAFO) program protects water quality by preventing animal wastes from discharging into waters of the state. ODA's CAFO program provides a means for the state to meet the requirements of the federal Clean Water Act. Operators know what is expected of them and are visited by ODA inspectors on an annual basis to insure compliance.	ORS 468B0.50 and 468B.0125	All permitted and non-permitted Confined Animal Feeding Operations.	In place, regulation ongoing
ODA	Pesticides	The ODA Pesticide Division regulates pesticide applicators, labeling, and regulates misuse.	Oregon State Pesticide Control Act, ORS 634, and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	All pesticide use throughout the state (commercial and private)	In place, regulation is ongoing
ODA	Soil and Water Conservation Districts	SWCDs identify and address natural resource concerns within their respective boundaries and work w/ local, state, federal and private interests to deliver conservation services.	Oregon's 45 SWCDs are organized under ORS Chapter 568 and are governed by an elected board of directors who serve without pay.	All lands within district boundaries	Program is in place, outreach and technical support is ongoing
ODA	Weed Control and Invasive Species	The Noxious Weed Control Program provides leadership and technical expertise for weed control programs throughout the state. ODA also tracks invasive exotic plants, insects and animals through a number of detection programs including reporting from citizens and other agencies.	The Oregon Invasive Species Council, which was created by the legislature, was initiated in 2002 with functions identified by ORS 561.685.	Non-regulatory program – weed control statewide (Federal, State, Public and Private lands)	Program is in place, outreach and implementation are ongoing
ODEQ	401 Dredge & Fill Certifications	Section 401 of the federal Clean Water Act requires that an applicant for a federal permit, to conduct an activity that may result in a discharge to waters of the State, must provide the permitting agency with a State water quality certification. A water quality certification is the mechanism by which the State evaluates whether an activity will meet water quality standards. Certifications may be denied, approved or approved with conditions, which if met, will ensure that water quality standards are met.	Federal Clean Water Act; ORS 468B.035 & .047; OAR 340-048	All waters of the State	In-place and on-going

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODEQ	401 Hydroelectric Recertification	Section 401 of the federal Clean Water Act requires that an applicant for a federal permit, to conduct an activity that may result in a discharge to waters of the State, must provide the permitting agency with a State water quality certification. A water quality certification is the mechanism by which the State evaluates whether an activity will meet water quality standards. Certifications may be denied, approved or approved with conditions, which if met, will ensure that water quality standards are met.	Federal Clean Water Act; ORS 468B.035 & 040 - .047; OAR 340-048	All waters of of the State	In-place and on-going
ODEQ	Environmental Clean Ups	DEQ's Environmental Cleanup Program protects human health and the environment by identifying, investigating, and remediating sites contaminated with hazardous substances. The Cleanup Programs objective is to guide all sites to No-Further-Action (NFA) determinations as quickly and inexpensively as possible. DEQ has issued over 1,000 NFAs since 1994, some of which include institutional or engineering controls to manage site risks.	Various Federal Laws; ORS465; OAR 340-122	All waters of of the State	In-place and on-going
ODEQ	Non-Point Source Program	DEQ requires Designated Management Agencies to develop Non Point Source Implementation Plan for sub basins that have TMDLs. Additionally, DEQ works in cooperation with other state, federal and local agencies to enhance their programs to address elements of non point source pollution and administers grants and loans to implement on-the-ground projects.	Federal Clean Water Act; ORS 468B.035	All waters of of the State	In-place and on-going
ODEQ	Point Source Permits	DEQ issues water quality permits to protect surface and ground waters of the state. These permits regulate sewage and industrial wastewater discharges from industrial and municipal sources.	Federal Clean Water Act; ORS 468B.035, 030 & 050; OAR 340-045.	All waters of of the State	In-place and on-going
ODEQ	Storm Water Permits	DEQ issues water quality permits to protect surface and ground waters of the state. Stormwater permits are required for and regulate storm water discharges to surface waters from: Construction activities (that disturb greater than 1 acre); industrial activities (subject to federal permitting requirements determined by SIC codes listed in the federal regulations); and municipalities (covered under Phase 1 (populations over 100,000) and Phase 2 (populations over 50,000) permitting requirements).	Federal Clean Water Act; ORS 468B.035, 030 & 050; OAR 340-045.	All waters of of the State	In-place and on-going

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.					
Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODEQ	Water Quality Standards	DEQ develops numeric and narrative water quality standards to protect for the most sensitive beneficial uses of the waters of the state – typically for protection of fish and other aquatic life and human health. As required under the Clean Water Act, these standards are to be reviewed every three years to insure that they are scientifically up-to-date.	Federal Clean Water Act; ORS 468B.035 & 048; OAR 340-041-0001 to 340-041-0350	All waters of of the State	In-place and on-going
ODF	Fire Program	The Fire Program of the Oregon Department of Forestry provides effective protection from fire for forest resources including water and watersheds, fisheries, wildlife, soil productivity and soil stability. National Fire Plan activities target fuel reduction and stand management that contribute to stands that are more fire resilient and benefit all forest resources. The Fire Program also educates forest landowners and forest homeowners about the value off fire hazard and risk reduction measures and takes positive action to minimize threats.	ORS Chapter 527, 526	Private forestlands, BLM land on Westside.	Program is active & ongoing.

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODF	Oregon Forest Practices Act	The FPA encourages economically efficient forest practices that ensure the continuous growing and harvesting of forest tree species and the maintenance of forestland for such purposes as the leading use on privately owned land consistent with sound management of soil, air, water, fish and wildlife resources. The FPA regulates road construction and road maintenance. Road construction must allow the migration of adult and juvenile fish upstream and downstream during conditions when fish movement in that stream normally occurs. For roads constructed after 1994, the forest practices act requires fish passage to be maintained. For all other roads the FPA encourages this standard. For roads constructed prior to 1994, other statutes apply that are outside the jurisdiction of the Department of Forestry. The water protection rules protect, maintain and, where appropriate, improve the functions and values of streams, lakes, wetlands, and riparian management areas. These functions and values include water quality, hydrologic functions, the growing and harvesting of trees, and fish and wildlife resources. Temperature is primarily addressed in the water protection rules that include general vegetation retention prescriptions for streams, lakes and wetlands. Requirements for vegetation along fish bearing streams varies by stream size and geographic region, however along all fish bearing streams, trees within 20 feet, vegetation within 10 feet, and trees leaning over the channel are required to be retained. Retention requirements beyond this vary. With regards to habitat complexity and off-channel habitat availability, the FPA regulates slash treatment, reforestation, chemical applications, road construction, harvesting, and hauling. Statutes and administrative rules vary for each practice, Each is designed to protect function and value of these resources. Requirements vary by stream size and geographic region, however along all fish bearing streams, trees within 20 feet, vegetation within 10 feet, and trees leaning over the channel are required to be retained. Retention requirements beyond this vary. These rules take a precautionary, passive approach by protecting the existing condition. They allow restoration activities only with site specific, written plans. With regards to fine sediment, the forest practices act regulates slash treatment, road construction, harvesting, and hauling. Rules vary for each practice. Each set of rules is designed to prevent or minimize sediment or debris delivery to waters of the state and to meet clean water standards. In addition to regulations for each specific practice, riparian buffers along fish bearing streams add an additional area of filtration between operation activities and waters of the state. A staff of field foresters works with landowners and operators to assist, educate, and enforce the rules. A statewide monitoring program assesses compliance with the rules and rule effectiveness at achieving objectives.	ORS Chapter 527, OAR Chapter 629	Operations on or pertaining to non-federal forestlands regardless of zoning or taxation, with the exception of where local governments (cities) have taken on responsibility of administering regulations within Urban Growth Boundaries that provide protection of forestland resources. Jurisdiction includes limited federal lands such as lands owned by Army Corp of Engineers, Bureau of Reclamation, and US Fish and Wildlife. USDA Forest Service and BLM lands are regulated through designation of those two agencies as the designated management agency under agreement with ODEQ. Operation means any commercial activity relating to the establishment, management or harvest of forest tree species. There are certain exceptions regarding Christmas trees, trees grown as intensive agriculture crops, trees grown to mitigate the effects of agricultural practices, and where approved land use conversions have commenced. See OAR 629-600-0100 (47).	Program is active & ongoing. Recent changes include wet weather hauling rules, road drainage, and measures around certain streams. Monitoring of small and medium fish bearing streams is under way. Board of Forestry work plan indicates evaluation of small non-fish bearing streams for temperature in 2008.

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODF	Private forestry component of the Oregon Plan for Salmon and Watersheds	Forest Landowners contribute to the Oregon Plan by complying with Oregon's Forest Practices Act and by accomplishing additional projects that contribute to Oregon Plan goals. Regarding fish passage, forest landowners close or rehabilitate legacy roads and update functioning roads to meet current standards, Oregon Plan measures on forestland are currently being updated to include recommendations from the work of the forest practices advisory committee and the DEQ sufficiency analysis. With regards to temperature, forest landowners manage riparian areas, leave additional conifers along streams, increase RMAs for non-fish bearing streams, and place leave trees to benefit Oregon Plan objectives. Oregon Plan measures on forestland are currently being updated to include recommendations from the work of the forest practices advisory committee and the DEQ sufficiency analysis. With regards to fine sediments, forest landowners voluntarily rehabilitate legacy roads to reduce the threat of fine sediment. This includes adding water bars, removing culverts, and pulling back perched soils on roads built prior to adoption of the FPA. Oregon Plan measures on private forestland are currently being updated to include recommendations from the work of the forest practices advisory committee and the DEQ sufficiency analysis. Regarding habitat complexity and off channel habitat availability, forest landowners place wood in streams, manage riparian areas, restore conifers in riparian management areas, and participate in habitat restoration activities. Oregon Plan measures on forestland are currently being updated to include recommendations from the work of the forest practices advisory committee and the DEQ sufficiency analysis.	ORS Chapter 521 and OAR 629-605-0103	Voluntary	Ongoing, updated voluntary measures planned for 2007.

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODF	State Forest Program	The State Forest Program implements actions related to roads to minimize effects upon fish passage. First, roads are built and maintained according to the standards of the Forest Roads Manual. Additionally, stream crossings are surveyed at the watershed scale to identify locations of potential effects to fish passage. (This is usually conducted through the watershed analysis process.) Based on these surveys, actions are taken to improve fish passage, where necessary. Finally, ODF conducts monitoring to ensure that actions are applied properly and to evaluate the effectiveness of these actions. The State Forest Program applies management standards for aquatic and riparian areas that include wide riparian buffers on fish bearing streams. These same standards apply to large and medium perennial streams without fish. Small perennial streams without fish also have tree retention requirements. ODF also applies additional risk-reduction strategies in Salmon Anchor Habitats (until 2011).. Finally, monitoring is conducted. ODF evaluates the effectiveness of its riparian strategies through its adaptive management program. The State Forest Program applies management standards for aquatic and riparian areas which are designed to increase the development of riparian large wood to restore aquatic habitats. These include a wider riparian management zone than specified under the FPA, with additional tree retention. Where appropriate, the FMP promotes the use of alternative vegetation treatments to accelerate the development of large wood. Active restoration is also applied to improve habitat complexity. Restoration projects include wood placement and re-routing of roads away from streams. Priority areas for restoration are generally identified through the watershed analysis process. Finally, monitoring is conducted. ODFW conducts monitoring to evaluate the effectiveness of restoration projects, while ODF evaluates the effectiveness of its riparian strategies through an adaptive management process. The State Forest Program implements actions related to roads and timber harvest to minimize the ability of sediment to reach streams. First, roads are built and maintained according to the standards of the Forest Roads Manual. Additionally, roads are surveyed at the watershed scale to identify locations of potential effects to streams. (This is usually conducted through the watershed analysis process.) Based on these surveys, actions are taken to reduce hydrologic connectivity, potential for road failure, and other potential sediment impacts. Timber harvest, likewise, is conducted to minimize sediment contributions to streams. The wide buffers specified by the Forest Management Plan prevent disturbance in the near stream area that might otherwise result in sediment delivery to streams. Finally, ODF conducts monitoring to ensure that actions are applied properly and to evaluate the effectiveness of these actions.	ORS Chapter 527, 521, OAR 629-640-0100 & -0200 through -0440, Northwest Oregon State Forests Management Plan, Forest Roads Manual, ODFW rules/statutes, OWEB guidance on fish passage	State Forest Land	

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODFW	Conservation Strategy for Oregon	Previously called the Comprehensive Wildlife Conservation Strategy, the Conservation Strategy for Oregon provides a non-regulatory, statewide approach to species and habitat conservation. It synthesizes existing plans, scientific data, and local knowledge into a broad vision and conceptual framework for long-term conservation of Oregon's native fish, wildlife and habitats. Conservation of instream and upland habitats will promote watershed health.	USFWS and Association of Fish and Wildlife Agencies guided the development and review process for the Strategy. For guidance on the implementation, see the Oregon Conservation Strategy document: http://www.dfw.state.or.us/conservationstrategy/	The Conservation Strategy for Oregon is meant to apply to all lands, rivers, streams, and estuaries in Oregon.	Internal review by January 2008; varying levels of external review to occur at 5 – and 10 – year intervals.
ODFW	Fish Passage Program	The owner or operator of an artificial obstruction located in waters in which native migratory fish are currently or were historically present must address fish passage requirements by gaining approval from ODFW prior to certain trigger events. Trigger events include installation, major replacement, a fundamental change in permit status (e.g., new water right, renewed hydroelectric license), or abandonment of the artificial obstruction. In addition, ODFW is working toward identification of the highest priority passage sites, at which passage can be addressed.	Laws regarding fish passage may be found in ORS 509.580 through 910 and in OAR 635, Division 412.	Artificial obstructions located in Oregon waters in which native migratory fish are currently or were historically present	ongoing
ODFW	Fish Screening and Passage Grant Program	Oregon water users may be eligible for an ODFW cost-share incentive program and state tax credit designed to promote the installation of ODFW approved fish screening or fish passage devices. Fish screens prevent fish from entering water diversions. Fishways provide fish passage to allow migration. ODFW works with owners who apply for funding, as well as actively seeks projects at which to provide fish screening and passage.	Laws regarding passage, screening, and cost share can be found in ORS 315.138, 496.085, 496.141, 496.303, 497.124, 498.301 through 346, 509.580 through 910, 537.141, 540.525, and in OAR 635, Division 412.	Oregon water users including independent agriculture users, private domestic users, municipal water suppliers, irrigation districts and commercial industries.	On-going

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODFW	Lands Resources Program	The Wildlife Division Land Resources Program helps guide land-use activities in Oregon that affect fish and wildlife habitats. The program offers tax incentives, grants and technical assistance to private and public landowners, businesses and governments to promote conservation of fish and wildlife habitats, and to ensure environmental protection standards are met. Programs goals promote healthy riparian and wetland corridors - decreasing bank erosion and filtering run-off.	OAR's for Landowner Incentive Program (LIP), Access and Habitat Program, Bird Stamp Program, and Riparian Lands Tax Incentive Program) can be found at http://arcweb.sos.state.or.us/rules/OARS_600/OAR_635/635_tofc.html	All owners of private and public land in Oregon interested in conserving fish and wildlife habitats.	Ongoing
ODFW	Restoration and Enhancement Program	ODFW oversees a comprehensive program to assist in enhancing natural fish production, improve hatchery programs, and provide additional public access to fishing waters. To achieve these goals, the R and E Program provides funding that directly benefits fish by addressing items such as fish passage, habitat restoration, public education, research and monitoring.	OAR's 635-009-0200 through -0240; Stat. Auth.: ORS 512	All streams, rivers, lakes, and estuaries in Oregon.	Ongoing.
ODFW	Salmon Trout Enhancement Program	The Salmon and Trout Enhancement Program (STEP) recognizes that volunteers play an important role in the restoration of salmon, steelhead and trout. STEP (1) educates the public about Oregon's salmon and trout resources and the habitats they depend on, (2) inventories and monitors fish populations and their habitat, (3) enhances, restores and protects habitat for native stocks of salmon, steelhead, and trout, and (4) produces fish to supplement natural fish production, augment fisheries, or, in the case of the classroom egg incubation program, provide educational opportunities. Habitat monitoring and enhancement function under STEP, could be used to address this limiting factor.	OAR's 635-009-0090 through -0150; Stat. Auth.: ORS 496	All Oregonians that are eager to contribute time, muscle, money, and perseverance to the restoration of salmon, steelhead and trout in Oregon.	Ongoing.
ODFW	Watershed Council Liaison	The ODFW Watershed Council Liaison position provides technical support to watershed councils involved in assessing watershed conditions and conducting restoration projects designed to address watershed needs. Among those projects are actions that specifically address fish passage barriers, iparian enhancement, habitat complexity, and fine sediments in streams.	Oregon Aquatic Habitat Restoration Guidelines.	All watershed councils in Oregon.	Not identified.
ODLCD	Statewide Comprehensive Land use Planning	Oregon's statewide comprehensive land use program requires cities and counties to plan for and manage land use in compliance with 19 statewide planning goals. Local land use plans and ordinances must identify and protect natural resources and identify and plan for hazard areas. The statewide land use program provides a framework for local governments to adopt land use plans and ordinances and approve development that are salmon-friendly.	(ORS 197,)RS 195, ORS 215, ORS 227)	City and county land use plans and ordinances.	Implementation is on-going. Plans and ordinances are updated according to local needs and as a result of legislation.

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
ODOT	Salmon-Fish Passage Program	Oregon Department of Transportation's (ODOT) Salmon-Fish Passage Program originated in 1997 through the Oregon Plan for Salmon and Watersheds (Oregon Plan). This program, initiated by Governor Kitzhaber and authorized by the Oregon Transportation Commission (OTC), defined ODOT's Oregon Plan contributions. The OTC invested $12 million Immediate Opportunity Funds prior to the 2000-2003 State Transportation Improvement Plan (STIP) to replace and retrofit high priority fish passage culverts owned and managed by ODOT. ODOT's Salmon-Fish Passage program funding levels continue to be approved by the OTC (FY 2008 through FY 2011 are $ 3.7, $ 3.9, $4.1, and $4.2 million respectively). ODOT's Salmon-Fish Passage Program has invested approximately $30 million into culvert improvements and provided access to nearly 370 miles of stream habitat once blocked to native migratory fish. These capital investment improvements, at culverts identified by Oregon Department of Fish and Wildlife (ODFW) as high priority fish passage locations, are critical elements of ODOT's Oregon Plan contributions. These projects promote the recovery and sustainability of threatened and endangered native migratory fish in Oregon. The goal of this program is to continue to support the Oregon Plan and to repair (replace or retrofit) priority fish passage culverts in the most aggressive, cost effective, and efficient means as practicable with limited program funds.	ORS 509-580 through 910, OAR Chapter 635-412-0010 through OAR 635-412-0040, Executive Order (EO) 99-01, and ODOT's Mission Statement	ODOT's Salmon-Fish Passage Program addresses fish passage needs at priority hydraulic facilities located within ODOT rights of way. These rights of way bisect multiple jurisdictions and land use.	ODOT's program is ongoing and presently funded through FY 2011. Funding requests through FY 2013 are complete and it is expected that the ODOT Salmon-Fish Passage Program will continue to be funded.
ODSL	Voluntary Restoration Initiative	Under DSL's new Voluntary Restoration Initiative, two Wetland Restoration Specialists are working with landowners and organizations interested in restoring wetlands. Primary objectives are to provide technical assistance on restoration site assessment, permitting and monitoring, facilitate restoration of historical wetland types (emphasis on rare and at-risk habitats), and accurately track/report quality/ quantity of projects	ORS Chapter 196.600-692; OAR 141-085-0240 -0257 and 0610-1660	Wetlands that meet the three wetland indicators described in the Corps of Engineers' 1987 Wetland Manual.	Initiative began in March 2006 and is scheduled as a 3-year program.
ODSL	Removal-Fill Program	Oregon's Removal-Fill Law requires people who plan to remove or fill material in waters of the state to obtain a permit from the Department of State Lands. Proposed permanent impacts to instream and off-channel habitat, as well as to wetlands, are required to be offset with compensatory mitigation actions such as riparian planting, large wood placement, or wetland restoration. All permits issued by DSL include conditions that require protection of fish habitat and water quality, including in-water timing restrictions, turbidity monitoring and sediment and erosion control requirements, and riparian vegetation removal restrictions and revegetation requirements. By offering streamlined General Authorizations for projects with minimal impacts (i.e. bioengineering methods and planting instead of riprap), the permit process encourages applicants to design projects with minimized impacts to water resources. The Department recently implemented a pilot program for an expedited permitting process for fish habitat enhancement activities including placement of large woody debris and boulders.	ORS Chapter 196.795 - 990 and ORS Chapter 390.835; OAR 141-085-0005 - 0165.	Waterways to the ordinary high water mark and wetlands that meet the three wetland indicators described in the Corps of Engineers' 1987 Wetlands Manual.	Program is ongoing

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
OWEB	CREP Program	OWEB is the state cost share partner for the Conservation Reserve Enhancement Program (CREP) that pays for riparian restoration and provides a 10-15 year conservation rental for maintenance of the plantings. The program has enrolled nearly 2,000 miles of stream since 1999.	ORS 541.351 - 541.420 and OAR 695-001-0000 through 695-050-0050	Agricultural lands	Ongoing
OWEB	Grant Program	OWEB's grant program supports voluntary efforts by Oregonians seeking to maintain and restore native fish and healthy watersheds. OWEB funds projects that restore, maintain, and enhance the state's watersheds, supports the capacity of local watershed-based citizen groups to carry out a variety of restoration projects, promotes citizen understanding of watershed needs and restoration ideas, provides technical skills to citizens working to restore urban and rural watersheds, and monitors the effectiveness of investments in watershed restoration. OWEB regular grants are awarded every 6 months for restoration and protection of ecological resources. Grant applications are reviewed by a regional multidisciplinary team to develop recommendations and prioritization of grant applications for OWEB consideration. The review teams evaluate whether the grant applications address limiting factors and the technical soundness of the proposals.	ORS 541.351 - 541.420 and OAR 695-001-0000 through 695-050-0050	All lands	Ongoing
OWRD	Administration of Water Rights	Surface waters in many areas of the state are fully allocated during critical flow periods for fish. However, there are several aspects of the review process for new water right applications that are protective of fish and fish habitat. All new groundwater permits are evaluated to determine the potential to cause substantial interference with surface flows. Surface water availability is modeled monthly and includes existing instream water rights. Applications to appropriate surface waters are evaluated at the 80% exceedance level. Permits are subject to public interest review standards that include interagency consultation on potential impacts of further appropriation to fish and fish habitat. All new water right applications are subject to review through an interagency review and consultation process. Permits, if approved, may be conditioned to address impacts on listed species identified through the consultation process.	OAR 690-009, 033, 051, 310	With few exceptions, all surface and ground waters of the state	Program is in place and ongoing
OWRD	Enclosed Livestock Water Delivery Systems	Livestock owners with legal access to use surface waters are exempt from the requirement to obtain a permit or certificate to divert water to a trough or tank through an enclosed water delivery system meeting minimum requirements. OWRD Watermasters provide technical support to interested landowners.	ORS 537.141	Water rights appurtenant to agricultural lands.	In place and ongoing

Appendix Table 1 (continued). Description of statewide programs currently implemented by the State of Oregon that support habitat management strategies in tributaries.

Agency	Program	Description	Guidance	Jurisdiction	Timeline
OWRD	Flow Restoration Programs	ODFW and OWRD have identified priority watersheds where flow restoration will produce the most benefit for listed species. OWRD staff work with water rights holders to restore streamflows through voluntary flow restoration measures. Voluntary measures include instream leases, instream transfers, allocations of water conserved through improved efficiencies, and changes to existing rights including consolidation or transfers of points of diversion. In certain circumstances, reclaimed water from certain municipal, industrial and confined animal feeding operations may provide an effective alternative to new diversions of surface water or ground water.	OAR 690-018, 077, 380	All interested water right holders	Program is in place, outreach, administration and technical assistance are ongoing
OWRD	Lease/Transfer Water Rights Associated with CREP Program	Perfected water rights appurtenant to lands enrolled under the CREP program are not subject to forfeiture for non-use during the enrollment period. OWRD encourages CREP participants to voluntarily lease or temporarily transfer associated water rights instream while enrolled in CREP. Associated water rights leased or transferred instream can be protected instream to benefit minimum flows and listed species.	ORS 537.348, 540.610 (Revised), OAR 690-077, 380	Water rights appurtenant to agricultural lands enrolled in CREP.	Program is in place, outreach, administration and technical assistance are ongoing
OWRD	Water Distribution and Regulation	Distribution and regulation of water use for the protection of senior water rights, including instream rights, is a priority for OWRD. Staff regularly monitor streamflow, particularly on those streams with established instream rights, and work to eliminate illegal use through compliance and enforcement of Oregon water law.	OAR 690-250, 077, ORS 540.045	With few exceptions, all surface and ground waters of the state	Program is in place. Distribution and regulation are ongoing.
OWRD	Water Supply and Conservation Planning	OWRD Staff work with water rights holders to address water supply through the development of water management and conservation plans. The development of these plans for new and extended municipal rights and through voluntary participation of irrigation districts must identify conservation measures that will be pursued. Municipal plans must also include five year benchmarks for implementation of conservation activities.	OAR 690-086 (Guidance is also available through the League of Oregon Cities)	Municipal and Agricultural water right holders interested in preparing, or required to prepare, water management and conservation plans.	In place and ongoing.
OWRD	Water Use Measurement Strategy	Federal and state agencies, cities, counties, schools, irrigation districts and other special districts are required to report water use on an annual basis. Since 1990, many new permits have required water meters to be installed and annual reports to be submitted to the state. In addition, the Water Resource Commission considered water use measurement in 2000 and adopted a strategy for improving water measurement statewide. The strategy includes a program to inventory and complete field assessments of significant points of diversion and to look for opportunities to increase measurement at those diversions by ensuring compliance and promoting voluntary measurement via cost-share programs. Significant diversions are characterized as those required to measure through a water right condition, or those diversions without a measurement condition that are greater than 5 cfs, or greater than 10% of the lowest monthly 50% exceedance flow as defined in the water availability model, and greater than 0.25 cfs.	OAR 690-085, ORS 537.099 and the Water Resource Commission's Strategy for Statewide Water Measurement	With few exceptions, all surface and ground waters of the state	Ongoing with partial implementation

Appendix 2. Strategies and land uses addressed by statewide management programs. A checked box indicates that the program addresses components of the management strategy or has jurisdiction over a land use. See Table 1 for a description of management strategy codes. Land use codes are: FF = Federal Forest; SF = State Forest; PF = Private Forest; Ag = Agriculture; UR = Urban/Rural residential;

		Management Strategy								Land use				
Agency	Program	1	2	3	4	5	6	7	8	FF	SF	PF	Ag	UR
ODA	Agricultural Water Quality Management (SB 1010)	√		√		√		√	√				√	
ODA	Confined Animal Feeding Operation (CAFO)							√	√				√	
ODA	Pesticides							√		√	√	√	√	√
ODA	Soil and Water Conservation Districts	√	√	√		√	√	√	√	√	√	√	√	√
ODA	Weed Control and Invasive Species	√		√		√		√	√	√	√	√	√	√
ODEQ	401 Dredge & Fill Certifications							√		√	√	√	√	√
ODEQ	401 Hydroelectric Recertification							√		√	√	√	√	√
ODEQ	Environmental Clean Ups							√		√	√	√	√	√
ODEQ	Non-Point Source Program					√		√		√	√	√	√	√
ODEQ	Point Source Permits							√						√
ODEQ	Storm Water Permits			√		√		√	√					√
ODEQ	TMDLs							√		√	√	√	√	√
ODEQ	Water Quality Standards							√		√	√	√	√	√
ODF	Fire Program	√	√	√	√	√		√	√	√		√		
ODF	Oregon Forest Practices Act	√	√	√	√	√	√	√	√		√	√	√	√

Appendix 2 (continued).

Agency	Program	Management Strategy								Land use				
		1	2	3	4	5	6	7	8	FF	SF	PF	Ag	UR
ODF	State Forest Program	√	√	√	√	√	√	√	√		√			
ODFW	Conservation Strategy for Oregon	√	√	√	√	√	√	√		√	√	√	√	√
ODFW	Fish Passage Program				√					√	√	√	√	√
ODFW	Fish Screening and Passage Grant Program				√							√	√	√
ODFW	Lands Resources Program	√	√	√	√	√	√	√		√	√	√	√	√
ODFW	Restoration and Enhancement Program	√	√	√	√	√	√	√		√	√	√	√	√
ODFW	Salmon Trout Enhancement Program	√	√	√	√	√	√	√		√	√	√	√	√
ODFW	Watershed Council Liaison	√	√	√	√	√	√	√		√	√	√	√	√
ODLCD	Statewide Comprehensive Land use Planning		√		√		√		√	√	√	√	√	√
ODOT	Salmon-Fish Passage Program				√					√	√	√	√	√
ODSL	Removal-Fill Program	√	√		√		√	√		√	√	√	√	√
ODSL	Voluntary Restoration Initiative	√	√				√			√	√	√	√	√
OWEB	CREP Program	√	√	√			√	√	√				√	
OWEB	Grant Program	√	√	√	√	√	√	√	√	√	√	√	√	√
OWRD	Administration of Water Rights				√	√				√	√	√	√	√
OWRD	Enclosed Livestock Water Delivery Systems			√									√	
OWRD	Flow Restoration Programs					√				√	√	√	√	√

Appendix 2 (continued).

Agency	Program	Management Strategy								Land use				
		1	2	3	4	5	6	7	8	FF	SF	PF	Ag	UR
OWRD	Lease/Transfer Water Rights Associated with CREP Program					√			√				√	
OWRD	Water Distribution and Regulation					√				√	√	√	√	√
OWRD	Water Supply and Conservation Planning					√							√	√
OWRD	Water Use Measurement Strategy					√				√	√	√	√	√

Appendix Table 3. Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODA	Agricultural Water Quality Management (SB 1010)		Basin plans and rules are reviewed biennially to determine whether the plan is sufficient to meet and address water quality standards, and modified as necessary to meet deficiencies and new requirements or information. Reviews include review of compliance actions, outreach activities, projects, and monitoring results. ODA focuses efforts and resources on areas of highest priority and program is enforced. "Compliance" is based on inspections prompted by "notification" of inappropriate occurrences; increasing complaints and notifications reflect an increased public awareness and greater number of basin rules in place. Water quality monitoring is conducted by DEQ at permanent sites. Aerial photography at 4-5 yr intervals documents riparian condition trends.	Biennial reviews will determine if modifications are needed. Given more resources (funding) implementation of on-the-ground actions, including monitoring, would be accelerated. More monitoring would provide improved documentation of program adequacy. Resources are needed for site capability assessment through GIS.	Landowner cooperation, capacity for outreach, changing land ownerships and new landowners knowledge of agricultural issues, perception that this is only a complaint driven process, technical assistance, adequate monitoring at meaningful scales
ODA	Soil and Water Conservation Districts		Strong local infrastructure, provides strong local involvement and action. Districts focus efforts and resources on areas of highest priority. An accounting of outreach activities and conservation planning and practices reported by SWCDs on an annual basis is available from ODA.	None at this time. Given more resources (funding) implementation of on-the-ground actions would be accelerated.	Stable and adequate levels of resources (Funding)
ODA	Weed Control and Invasive Species		Weed and invasive species negatively affect desired riparian condition and function. ODA focuses efforts and resources on areas of highest priority. This is a voluntary program and not under regulatory control	None at this time. Given more resources (funding) implementation of on-the-ground actions would be accelerated.	Adequate technical support, capacity for outreach, perception that this is not doable because it is an ongoing challenge
ODEQ	401 Dredge & Fill Certifications		Limited monitoring for compliance and lack of cumulative impacts tracking.	A greater number of specific types of projects will be monitored for compliance in the future. This will help in evaluating adequacy of portions of the program but additional monitoring and evaluation is needed.	The state review is primarily fee based. Fees need to be periodically adjusted to cover the cost of the program.
ODEQ	Non-Point Source Program		The program relies on existing state and local authorities to address non point sources of pollution. Programs to address nonpoint sources, especially in urban and agricultural areas, are relatively recent and additional time and trend monitoring is needed to document results. Additionally, while a schedule for implementation is to be identified, timing of implementation is often dependent on adequate future funding which often is not guaranteed or certain.	Adequate monitoring program needed; see other programs listed in this document for modifications needed as it relies on other existing state and local authorities for implementation. See other programs listed in this document for Modifications Needed,	See other programs listed in this document for constraints as it relies on other existing state and local authorities for implementation.
ODEQ	Storm Water Permits		Stormwater permitting program is: - a relatively recent program where programs, practices and technology are evolving (e.g. phase 2 permits are being developed by 2007) and therefore there has been limited time to monitor the effectiveness of this program; - In the case of municipal storm water, permits require implementation of best management practices to the maximum extent practicable which may not restore upland processes or may not water quality standards in some areas.	Additional staff for technical assistance and program oversight. Additional Staffing.	Number of staff is always a limitation. Funding is a blend of federal, state and fee support. Additional funding has recently been provided based on a Blue Ribbon Committee Report which recommended changes to fee structures and additional general funds.

Appendix Table 3 (continued). Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODEQ	TMDLs		TMDLs target bringing waters back into compliance with water quality standards. Oregon entered into a Consent Decree and Memorandum of Agreement with USEPA in 2000 under which it committed to substantially complete TMDLs statewide by 2010 (based on number of waters listed on the 1998 303(d) list). Uncertainty is based on the fact that sedimentation is likely to underlisted and therefore only a few sedimentation TMDLs have been developed in Oregon. Additionally, DEQ has not had much experience in addressing sedimentation under the TMDL program.	The Department is currently working on updating the turbidity standard and has identified that the sedimentation standard needs to be addressed in future triennial standards reviews. The Department is also re-examining its 303(d) listing criteria based on the current narrative standard. Subsequent sedimentation TMDLs will address these concerns. Additional Staffing.	Staffing resources.
ODEQ	Water Quality Standards		A growing backlog of standards need to be updated. At current staffing levels, DEQ cannot update standards on a three year cycle nor undertake complex standard development that would be needed to adequately address complex issues such as sedimentation and turbidity. Without updates, DEQ would rely on current standards or those promulgated by the USEPA. In the case of addressing sedimentation, DEQ relies on use of its current narrative standard.	Additional staffing for this program (DEQ had a preliminary budget request in for the 2007 Legislature, but did receive the Governor's approval).	Number of staff

Appendix Table 3 (continued). Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Fire Program		Resources are needed to assist forest landowners to reduce fuels that place forested watersheds at risk. Infrastructure is also needed to support resource enhancement opportunities through biomass conversion projects.	More coordinated efforts by all of Oregon's agencies and landowners to work collaboratively with federal partners to increase the contribution for recovery from federal forests.	Federal and private forest 'checker-board' ownership can place private forestlands at risk for uncharacteristic wildfire when either forest is not managed. There is a need for both ODF and ODF&W, and all landowners to play a role in the management of federal forests located in Oregon. A collaborative relationship between state natural resource agencies and federal forest management agencies may restore the health, diversity, and resilience of federal forests by increasing the information shared and by providing a variety of perspectives on site-specific and landscape level determinations. Wildfire-prone areas are identified in a community wildfire protection plans identifying priority areas for hazardous fuel removal from federal lands.

Appendix Table 3 (continued). Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Oregon Forest Practices Act		Current practices under the Act have reduced sediment inputs and will sustain a trend of reducing fine sediment inputs over time. Past activities that have unnecessarily contributed fine sediments have been abandoned or modified. Modifications to practices have been designed to address the key mechanisms for delivery of fine sediment from forest operations. Legacy issues are addressed over time through the regulatory process when culverts are replaced or roads become part of an active operation. Legacy issues are also addressed in an expedited manner through voluntary measures. Documentation Links: Final Oregon Coastal Coho Assessment: http://nrimp.dfw.state.or.us/OregonPlan Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality, ODF and DEQ 2002. Pages 6, 7 (Wet Weather road use rules subsequently adopted.) Pgs. 6-7, 32-35, 59-61, C3-8. http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/AllSAv1031.pdf ODF BMP Compliance study 2002 pages 19-25 http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/BMPfinalTR15.pdf Additional monitoring: o Road Hazard Inventory (pdf) o FPMP Technical Report #17 (pdf) - Wet Season Road Use Monitoring Project: Final Report, June 2003 o FPMP Technical Report #8 (pdf), Evaluation of the Effectiveness of Forest Road BMPs to Minimize Stream Sediment Impacts - Final FY 96 Report to the Oregon DEQ o FPMP Technical Report #9 (pdf), Forest Roads, Drainage, and Sediment Delivery in the Kilchis River Watershed, June 1997 o FPMP Technical Report #10 (pdf), Forest Road Sediment and Drainage Monitoring Project Report for Private and State Lands in Western Oregon, February 1998 o Storm Impacts & Landslides of 1996 : http://egov.oregon.gov/ODF/PRIVATE_FORESTS/landslides.shtml	Additional resources for monitoring and program implementation would increase the certainty that the current rules are efficient and effective at delivering desired outcomes. The Board of Forestry has adopted an indicator to address road related risks. The metrics for the indicator are: 1) Percent of road system disconnected from the stream network; 2) Percent of stream crossings on fish streams providing passage; 3) Land area in non-forest condition due to roads (road subgrade plus cutslope). The desired trend is an increasing proportion of sampled Oregon forest roads are determined to pose a low risk to soil and water resources. Additional resources and interagency coordination are needed to implement this indicator.	Resources and collaboration remain constraining. Current resource needs include the resources necessary to implement Forestry Program for Oregon indicator monitoring for roads and fish passage and the resources necessary to conduct more Private Forests Program compliance and effectiveness monitoring.

Appendix Table 3 (continued). Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Private forestry component of the Oregon Plan for Salmon and Watersheds		The trend for fine sediment regimes is clearly improving. Past practices that contributed fine sediments have been abandoned or modified. Existing rules regulate practices on current operations. Voluntary investments mitigate legacy sediment problems. The Oregon Plan is designed to address known sources of sediment not addressed as active operations under the Forest Practices Act. The contribution of sediment from these sources is unknown as is the total amount of work that would be needed to address these sources. Considering this uncertainty, adequacy of the program is deemed likely. Reporting and communication indicate that many landowners actively participate in the Oregon Plan and road work on roads built prior to the adoption of the Oregon forest practices act has become routine maintenance for many landowners. OWEB Watershed Restoration Inventory data indicates that landowners are actively participating in the Oregon Plan. Documentation Oregon Watershed Enhancement Board Watershed Restoration Inventory	More resources to inventory roads, especially on small, non-industrial private lands, would increase our understanding of legacy roads, fine sediment and the links to listed species	As always, more resources would increase project accomplishment, education, coordination, and monitoring.
ODF	State Forest Program		The program is built on a sound theoretical basis. Similar practices to those employed by ODF have been proven to reduce sediment production, transport, and delivery in other studies. While this gives reason to believe that the FMP standards are effective, the degree of effectiveness has not yet been established because monitoring is not yet complete. Documentation Because program standards meet or exceed those under the FPA, the documentation listed to support the sufficiency of the FPA will also support the sufficiency of the State Forests Program. Future monitoring reports produced by the State Forests Program will likely document any additional benefits produced by FMP strategies.	The need for modification to the current program is uncertain, pending the results of monitoring.	Staffing and funding are the major constraints to sediment reduction projects. While new roads are built according to current standards, and road maintenance is ongoing, improvements to existing roads are scheduled as time and funding allows.
ODFW	Conservation Strategy for Oregon		The Oregon Conservation Strategy is a new voluntary program. As such, monitoring and evaluation will be necessary to determine the effectiveness of the program.	None at this time. The role of this new program as it pertains specfically to listed salmon and steelhead is still being defined.	Voluntary measures – no assurance that it will be implemented
ODFW	Lands Resources Program		Uncertain of funding status or participation by public and private entities (i.e. Riparian Lands Tax Incentive Program).	Need further promotion of existing programs by I and E, Wildlife Division, and District staff.	Funding and staff time.

Appendix Table 3 (continued). Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODFW	Restoration and Enhancement Program		Funding for this program is through a surcharge imposed on all sport fishing licenses and commercial salmon fishing licenses and poundage fees. As such, funding is a subject to annual variations in fish abundance, harvest rates, and license sales.	None. The Program will evaluate their ability to shift resources to priorities that emerge from recovery planning. Further changes in program scope and focus would require legislative action.	Broad legal mandates of the program limit the ability of the program to focus solely on the needs of recovery planning, variable funding due to funding mechanism.
ODFW	Salmon Trout Enhancement Program		Current staffing and the broad scope of the program limits the capacity of the program to address any single program element.	Additional funding, additional FTE.	Funding.
ODFW	Watershed Council Liaison		Currently there are only two watershed council liaison positions in ODFW, both in the North Coast Watershed District. There are no positions for other regions of Oregon.	New positions.	Funding.
ODLCD	Statewide Comprehensive Land Use Planning		The land use actions taken by local governments can supplement and support other specific restoration activities but are not sufficient in themselves to achieve restoration. Local land use actions will likely not remediate legacy conditions or significantly alter current practices, but will affect future development.	None. The statewide land use program is not intended to be sufficient to recover salmon.	Technical and planning assistance to local governments would be highly beneficial in enlisting local planning efforts in salmon recovery.
ODSL	Removal-Fill Program		DSL's removal-fill permits include conditions designed to protect water quality, including turbidity monitoring and sediment and erosion control rquirements. Not enough projects are monitored for compliance.	A greater number of projects need to be monitored for compliance. Additional, permanent compliance staff are needed.	The half-time Compliance Monitoring Specialist position is funded for three years and is subject to reauthorization each year of the three year period. The status of the position is uncertain after that time.
OWEB	CREP Program		Limitation on recruiting private landowners for voluntary water quality restoration projects. Limitation to water quality restoration opportunities due to existing infrastructure. The limitation of CREP technical assistance has been demonstrated to be the single most important factor linked to enrollment.	Increased capital and non-capital funds	Funding
OWEB	Grant Program		There is a limitation on local capacity to provide the landowner outreach, project design and facilitate implementation to address agricultural management, forest management and urban runoff that affects sediment delivery to streams.	Increased funds available to support local conservation capacity in watershed councils and soil and water conservation districts. A direct conversation with the industrial forest landowners about identifying ways to further address forest road runoff.	Funding and focus for effort by land use category (forest, urban and agriculture).

Appendix Table 3 (continued). Program sufficiencies to address fine sediment impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
OWRD	Enclosed Livestock Water Delivery Systems		When combined with riparian fencing programs, opportunities to protect and restore riparian communities, including filtering of fine sediments, while providing livestock watering capabilities are increased. There is currently no monitoring program in place to evaluate program effectiveness.	No modifications to program design are proposed. The program would benefit from expanded outreach and education.	The program is reliant on landowner interest. Construction and subsequent maintenance of fencing and off-channel watering devices require adequate financial resources.

Appendix Table 4. Program sufficiencies to address habitat complexity impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODA	Soil and Water Conservation Districts		Strong local infrastructure, provides strong local involvement and action. Districts focus efforts and resources on areas of highest priority. However, addressing this limiting factor requires a reduction in productive land which is not a priority for landowners. There is no monitoring to demonstrate effectiveness.	None at this time. Given more resources (funding) implementation of on-the-ground actions would be accelerated. Incentives are needed to foster landowner buy-in.	Stable and adequate levels of resources (Funding). Conflict with landowner values and priorities.
ODF	Fire Program		Resources are needed to assist forest landowners to reduce fuels that place forested watersheds at risk. Infrastructure is also needed to support resource enhancement opportunities through biomass conversion projects.	More coordinated efforts by all of Oregon's agencies and landowners to work collaboratively with federal partners to increase the contribution for recovery from federal forests.	Federal and private forest 'checker-board' ownership can place private forestlands at risk for uncharacteristic wildfire when either forest is not managed. There is a need for both ODF and ODF&W, and all landowners to play a role in the management of federal forests located in Oregon. A collaborative relationship between state natural resource agencies and federal forest management agencies may restore the health, diversity, and resilience of federal forests by increasing the information shared and by providing a variety of perspectives on site-specific and landscape level determinations. Wildfire-prone areas are identified in a community wildfire protection plans identifying priority areas for hazardous fuel removal from federal lands.

Appendix Table 4. Program sufficiencies to address habitat complexity impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Oregon Forest Practices Act		The trend should be improving for in-stream habitat complexity and off channel availability. Vegetation retention along streams was not required until FPA rules were first established in 1972. Vegetation retention standards were revised in 1983, 1987, 1994, and 2006. Under the current Forest Practices Act, riparian areas are designed to provide the vegetation necessary for riparian functions including shade, large wood, and nutrients. A monitoring program is in place and an adaptive management process incorporates information. Rules are modified as necessary to meet the goals for riparian function and water quality. The existing vegetation in these riparian management areas will mature and provide these functions; however this will take many decades to occur. In the short term, landowners make voluntary contributions to habitat complexity through the Oregon Plan. Documentation Links Final Oregon Coastal Coho Assessment: http://nrimp.dfw.state.or.us/OregonPlan Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality, ODF and DEQ 2002. http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/AllSAv1031.pdf Harvest Effects on Riparian Function & Structure o FPMP Technical Report #12 (pdf) - Harvest Effects on Riparian Function and Structure , July 2001 o Executive Summary (pdf)	Evaluation of the vegetation retention requirements along western Oregon small and medium fish-bearing streams is underway. If modifications are needed, methods to accomplish these modifications through regulatory and non-regulatory means will be considered.	Lack of production functions for fish populations and habitat conditions is a major constraint. Lack of incentives and technical assistance to provide forest landowners more site-specific options is also a major constraint.

Appendix Table 4 (continued). Program sufficiencies to address habitat complexity impacts

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Private forestry component of the Oregon Plan for Salmon and Watersheds		The protection and voluntary measures should result in improving trends for in-stream habitat complexity and off channel availability. Under the Forest Practices Act, riparian areas are designed to provide the vegetation necessary for riparian functions including shade, large wood, and nutrients.. A monitoring program is in place, and an adaptive management process incorporates information. Rules are modified as necessary to meet the goals for riparian function. The existing vegetation in these riparian management areas will mature and provide these functions; however this will take many decades to occur. In the short term, landowners make voluntary contributions to improve habitat complexity through the Oregon Plan. Through the voluntary measures, the temporal and spatial opportunities for improvements are greatly accelerated. Forest landowners are contributing directly to the habitat complexity and off-channel availability by actively placing large wood during the course of forest operations. While not yet fully systematic, the proportion of operations conducting restoration as part of the operation should increase over time. Prioritization concepts, such as high aquatic potential are being developed. Documentation Links Oregon Watershed Enhancement Board Watershed Restoration Inventory OAR 629-640-0105: Placing Large Wood Key Pieces in Type F Streams to Improve Fish Habitat: This rule streamlines the process for placing large wood when conducted during a forest operation under the FPA. It is anticipated that this new rule will facilitate increased voluntary placement of large wood. This assessment is based on more than just monitoring. Every “call” is based on monitoring, rules, policies, incentives, education, and guidance.	More information about the needs and priorities would assist landowners in efficiently spending limited resources. Monitoring of effectiveness could be improved	Sufficient incentives are necessary to increase the scope of non-regulatory measures to match the needs. More stewardship foresters and habitat biologists are necessary to support the commitment landowners have willingly made. This would strengthen the educational component and complement the technical assistance from ODF, ODF&W, and OSU Extension foresters.

Appendix Table 4 (continued). Program sufficiencies to address habitat complexity impacts

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	State Forest Program		The program is built on a sound theoretical basis. Similar practices to those employed by ODF have been proven to improve fish habitats and populations in other studies. While this gives reason to believe that the FMP standards are effective, the degree of effectiveness has not yet been established because monitoring is not yet complete. Documentation Because program standards meet or exceed those under the FPA, the documentation listed to support the sufficiency of the FPA will also support the sufficiency of the State Forests Program. Future monitoring reports produced by the State Forests Program will likely document any additional benefits produced by FMP strategies.	The need for modification to the current program is uncertain, pending the results of monitoring.	Staffing and funding are the major constraints to habitat restoration projects. Projects are generally conducted opportunistically in connection with timber sales. Additional projects could be conducted with increased staffing and funding.
ODFW	Conservation Strategy for Oregon		The Oregon Conservation Strategy is a new voluntary program. As such, monitoring and evaluation will be necessary to determine the effectiveness of the program.	None at this time. The role of this new program as it pertains specifically to listed salmon and steelhead is still being defined.	Voluntary measures – no assurance that it will be implemented
ODFW	Lands Resources Program		Uncertain of funding status or participation by public and private entities (i.e. Riparian Lands Tax Incentive Program).	Need further promotion of existing programs by I and E, Wildlife Division, and District staff.	Funding and staff time.
ODFW	Restoration and Enhancement Program		Funding for this program is through a surcharge imposed on all sport fishing licenses and commercial salmon fishing licenses and poundage fees. As such, funding is a subject to annual variations in fish abundance, harvest rates, and license sales.	None. The Program will evaluate their ability to shift resources to priorities that emerge from recovery planning. Further changes in program scope and focus would require legislative action.	Broad legal mandates of the program limit the ability of the program to focus solely on the needs of recovery planning, variable funding due to funding mechanism.
ODFW	Salmon Trout Enhancement Program		Current staffing and the broad scope of the program limits the capacity of the program to address any single program element.	Additional funding, additional FTE.	Funding.
ODFW	Watershed Council Liaison		Currently there are only two watershed council liaison positions in ODFW, both in the North Coast Watershed District. There are no positions for other regions of Oregon.	New positions.	Funding.
ODLCD	Statewide Comprehensive Land Use Planning		The land use actions taken by local governments can supplement and support other specific restoration activities but are not sufficient in themselves to achieve restoration. Local land use actions will likely not remediate legacy conditions or significantly alter current practices, but will affect future development.	None. The statewide land use program is not intended to be sufficient to recover salmon.	Technical and planning assistance to local governments would be highly beneficial in enlisting local planning efforts in salmon recovery.

Appendix Table 4 (continued). Program sufficiencies to address habitat complexity impacts

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODSL	Removal-Fill Program		DSL's removal-fill permitting process encourages protection and restoration of instream and off channel habitat and wetlands. At current staffing levels, DSL does not always have the resources to do the outreach necessary to encourage landowners to protect and restore water resources.	Additional funding would increase the effectiveness of the program.	The fact that DSL does not have jurisdiction over the removal of large wood hinders our ability to protect instream and off- channel habitat.
ODSL	Voluntary Restoration Initiative		The Initiative provides direct technical assistance to landowners and organizations involved in restoring wetlands that provide off channel habitat. Because the Initiative is only funded for three years, its impact will be too limited to significantly address the threat of off channel habitat loss. The Initiative is too new to document program effectiveness.	Converting this three-year program to a permanent program would increase effectiveness. The Initiative is too new to determine what program modifications might be needed.	The Initiative is funded for three years and is subject to reauthorization each year of the three-year period. The status of the program is uncertain after that time.
OWEB	CREP Program		Limitation on recruiting private landowners for voluntary water quality restoration projects. Limitation to water quality restoration opportunities due to existing infrastructure. The limitation of CREP technical assistance has been demonstrated to be the single most important factor linked to enrollment.	Increased capital and non-capital funds	Funding
OWEB	Grant Program		Limitation on technical assistance to design floodplain restoration and stream complexity projects that can provide benefits through the range of natural flow conditions. Limitation on recruiting private landowners for voluntary floodplain restoration project implementation and protection and restoration of side-channel habitat. Limitation to floodplain and side-channel restoration and protection opportunities due to existing infrastructure.	Increased funding for technical assistance for project design and outreach to engage landowners. Effectiveness monitoring of large wood placement projects to answer questions about the stability and movement of large wood through Oregon streams.	Funding

Appendix Table 5. Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODA	Agricultural Water Quality Management (SB 1010)		Basin plans and rules are reviewed biennially to determine whether the plan is sufficient to meet and address water quality standards, and modified as necessary to meet deficiencies and new requirements or information. Reviews include review of compliance actions, outreach activities, projects, and monitoring results. ODA focuses efforts and resources on areas of highest priority and program is enforced. "Compliance" is based on inspections prompted by "notification" of inappropriate occurrences; increasing complaints and notifications reflect an increased public awareness and greater number of basin rules in place. Water quality monitoring is conducted by DEQ at permanent sites. Aerial photography at 4-5 yr intervals documents riparian condition trends.	Biennial reviews will determine if modifications are needed. Given more resources (funding) implementation of on-the-ground actions, including monitoring, would be accelerated. More monitoring would provide improved documentation of program adequacy.	Landowner cooperation, capacity for outreach, changing land ownerships and new landowners knowledge of agricultural issues, perception that this is only a complaint driven process, technical assistance, adequate monitoring at meaningful scales
ODA	Soil and Water Conservation Districts		Strong local infrastructure, provides strong local involvement and action. Districts focus efforts and resources on areas of highest priority. An accounting of outreach activities and conservation planning and practices reported by SWCDs on an annual basis is available from ODA.	None at this time. Given more resources (funding) implementation of on-the-ground actions would be accelerated. Additional measurement of program effectiveness is needed through documentation of habitat improvement.	Stable and adequate levels of resources (Funding)
ODEQ	401 Hydroelectric Recertification		Certifications are based on review that the proposed project will meet water quality standards. Given that most major hydroelectric projects are going through relicensing and that some actions will be based on further monitoring and adaptive management strategies (monitoring and adaptive management needs are specified for each project), additional data will be collected in the future to document program effectiveness. Documentation will be developed as part of the TMDL implementation process.	Additional Funding and Staff	the state review is primarily fee based. Fees need to be periodically adjusted to cover the cost of the program
ODEQ	Non-Point Source Program		The program relies on existing state and local authorities to address non point sources of pollution. Programs to address nonpoint sources, especially in urban and agricultural areas, are relatively recent and additional time and trend monitoring is needed to document results. Additionally, while a schedule for implementation is to be identified, timing of implementation is often dependent on adequate future funding which often is not guaranteed or certain.	Adequate monitoring program needed; see other programs listed in this document for modifications needed as it relies on other existing state and local authorities for implementation. See other programs listed in this document for Modifications Needed.	See other programs listed in this document for constraints as it relies on other existing state and local authorities for implementation.

Appendix Table 5. Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODEQ	Point Source Permits		Permits are written to meet water quality standards, sources not in compliance have to come into compliance within the permit cycle (typically, 5 years). Compliance monitoring is required. Permits are reviewed and updated on at least 5-year basis or as needed, based on new requirements. Additionally, the TMDL program can require additional treatment to meet water quality based conditions. The CWA has a citizen lawsuit provision which is an effective oversight provision for permitting. Studies are required as part of the permit process, including mixing zones surveys. Additional data and reports are available through ODEQ.	None	Number of staff is always a limitation. Funding is a blend of federal, state and fee support. Additional funding has recently been provided based on a Blue Ribbon Committee Report which recommended changes to fee structures and additional general funds.

Appendix Table 5. (continued). Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODEQ	TMDLs		TMDLs target bringing waters back into compliance with water quality standards. Oregon entered into a Consent Decree and Memorandum of Agreement with USEPA in 2000 under which it committed to substantially complete TMDLs statewide by 2010 (based on number of waters listed on the 1998 303(d) list). Most of the subbasins in Oregon are listed for temperature with TMDLs developed to address temperature issues for the entire subbasin. Therefore, most of the state should have TMDLs for temperature in the coming years. Implementation follows the TMDLs although there are many programs already in place in much of Oregon. Given that this program is fairly new and it will take years to decades to address degraded riparian conditions, there is limited documentation on the effectiveness of TMDL-related programs to address temperature. TMDL processes will be a condition of 401 hydroelectric certifications	Additional Staffing.	Staffing resources.
ODEQ	Water Quality Standards		Temperature Standards were recently updated (December 2003) and approved by the U.S. Environmental Protection Agency (March 2004). The numeric and narrative criteria, when achieved, should protect fish and other aquatic life in all life stages. Given that the criteria were adopted recently, programs that target achieving these criteria have been recently modified or developed, therefore field documentation of the effectiveness of the standard to protect fish is limited. Documentation will be developed as part of the TMDL process.	Additional staffing for this program (DEQ had a preliminary budget request in for the 2007 Legislature, but did receive the Governor's approval).	Number of staff

Appendix Table 5. (continued). Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Fire Program		Resources are needed to assist forest landowners to reduce fuels that place forested watersheds at risk. Infrastructure is also needed to support resource enhancement opportunities through biomass conversion projects.	More coordinated efforts by all of Oregon's agencies and landowners to work collaboratively with federal partners to increase the contribution for recovery from federal forests.	Federal and private forest 'checker-board' ownership can place private forestlands at risk for uncharacteristic wildfire when either forest is not managed. There is a need for both ODF and ODF&W, and all landowners to play a role in the management of federal forests located in Oregon. A collaborative relationship between state natural resource agencies and federal forest management agencies may restore the health, diversity, and resilience of federal forests by increasing the information shared and by providing a variety of perspectives on site-specific and landscape level determinations. Wildfire-prone areas are identified in a community wildfire protection plans identifying priority areas for hazardous fuel removal from federal lands.

Appendix Table 5. (continued). Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Oregon Forest Practices Act		Shade levels for streams on forestlands are consistently measured at high levels. A sufficiency analysis established that on a landscape level and for most streams the water quality standards are being met by the current rules. Areas of concern that were identified were limited and increments of temperature change that might result from the areas of concern are not of the magnitude to result in adverse stress or mortality. The relationships among temperature, sunlight, and fish productivity in some streams is being evaluated in several large research projects including an ODF riparian function study, the Hinkle Creek watershed study, and the Trask River watershed study. An adaptive management process will incorporate monitoring and research results into the Forest Practices Act. Documentation Links Final Oregon Coastal Coho Assessment: http://nrimp.dfw.state.or.us/OregonPlan Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality, ODF and DEQ 2002. http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/AllSAv1031.pdf Stream Temperature Monitoring o FPMP Technical Report #2 (pdf), Cooperative Stream Temperature Monitoring: Project Completion Report For 1994 - 1995 (Small Type N Streams), Sept. 1999 o FPMP Technical Report #3 (pdf), Effectiveness of Riparian Management Areas and Hardwood Conversions in Maintaining Stream Temperature, March 1997 Shade Quality Study o FPMP Technical Report #13 (pdf) - Shade Conditions Over Forested Streams in the Blue Mtn and Coast Range Georegions of Oregon, August 2001 o Executive Summary (pdf)	Research and monitoring is currently under way to determine the linkages am	Funding for existing and planned research and monitoring projects is critical to understanding water temperature, riparian conditions, and stress and mortality of salmon and steelhead. These studies span multiple years of data collection and take a long-term commitment of funding and resources to provide feedback to inform policy decisions.

Appendix Table 5. (continued). Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Private forestry component of the Oregon Plan for Salmon and Watersheds		The trend for water temperature is improving. Oregon Plan measures contribute to developing healthy riparian stand conditions that are presumed necessary for salmonids and water temperature, The Oregon Plan is designed to decrease the time to get to healthy conditions through active management. Where landowners choose not to participate in the Oregon Plan, standard Oregon Forest Practices RMA protections apply that develop healthy riparian conditions through passive management. Documentation Oregon Watershed Enhancement Board Watershed Restoration Inventory	Modifications should keep pace with best available science.	Funding for existing and planned monitoring projects is critical to understanding water temperature, riparian conditions, and stress and mortality of salmon and steelhead. These studies span multiple years of data collection and take a long term commitment of funding and resources to provide feedback to inform policy decisions. More resources would increase project accomplishment, education, and coordination.
ODF	State Forest Program		The program is built on a sound theoretical basis: The FMP provides for shade along fish-bearing streams. While this gives reason to believe that the FMP standards are effective, the degree of effectiveness has not yet been established because monitoring is not yet complete. Documentation Because program standards meet or exceed those under the FPA, the documentation listed to support the sufficiency of the FPA will also support the sufficiency of the State Forests Program. Future monitoring reports produced by the State Forests Program will likely document any additional benefits produced by FMP strategies.	The need for modification to the current program is uncertain, pending the results of monitoring.	None identified.
ODFW	Conservation Strategy for Oregon		The Oregon Conservation Strategy is a new voluntary program. As such, monitoring and evaluation will be necessary to determine the effectiveness of the program.	None at this time. The role of this new program as it pertains specfically to listed salmon and steelhead is still being defined.	Voluntary measures – no assurance that it will be implemented.
ODFW	Lands Resources Program		Uncertain of funding status or participation by public and private entities (i.e. Riparian Lands Tax Incentive Program).	Need further promotion of existing programs by I and E, Wildlife Division, and District staff.	Funding and staff time.
ODFW	Restoration and Enhancement Program		Funding for this program is through a surcharge imposed on all sport fishing licenses and commercial salmon fishing licenses and poundage fees. As such, funding is a subject to annual variations in fish abundance, harvest rates, and license sales.	None. The Program will evaluate their ability to shift resources to priorities that emerge from recovery planning. Further changes in program scope and focus would require legislative action.	Broad legal mandates of the program limit the ability of the program to focus solely on the needs of recovery planning, variable funding due to funding mechanism.
ODFW	Salmon Trout Enhancement Program		Current staffing and the broad scope of the program limits the capacity of the program to address any single program element.	Additional funding, additional FTE.	Funding.

Appendix Table 5. (continued). Program sufficiencies to address water temperature impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODFW	Watershed Council Liaison		Currently there are only two watershed council liaison positions in ODFW, both in the North Coast Watershed District. There are no positions for other regions of Oregon.	New positions.	Funding.
ODSL	Removal-Fill Program		DSL's removal-fill permits include conditions designed to protect water quality, including riparian vegetation removal restrictions and revegetation requirements. Not enough projects are monitored for compliance.	Modifications Needed: A greater number of projects need to be monitored for compliance. Additional, permanent compliance staff are needed.	The half-time Compliance Monitoring Specialist position is funded for three years and is subject to reauthorization each year of the three-year period. The status of the position is uncertain after that time.
OWEB	CREP Program		Limitation on recruiting private landowners for voluntary water quality restoration projects. Limitation to water quality restoration opportunities due to existing infrastructure. The limitation of CREP technical assistance has been demonstrated to be the single most important factor linked to enrollment.	Increased capital and non-capital funds	Funding
OWEB	Grant Program		Limitation on recruiting private landowners for voluntary water quality restoration projects. Limitation to water quality restoration opportunities due to existing infrastructure.	Increased capital and non-capital funds	Funding
OWRD	Enclosed Livestock Water Delivery Systems		When combined with riparian fencing programs, opportunities to protect and restore riparian communities, including filtering of fine sediments, while providing livestock watering capabilities are increased. There is currently no monitoring program in place to evaluate program effectiveness.	No modifications to program design are proposed. The program would benefit from expanded outreach and education.	The program is reliant on landowner interest. Construction and subsequent maintenance of fencing and off-channel watering devices require adequate financial resources.

Appendix 6. Program sufficiencies to address fish passage impacts.					
Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	Oregon Forest Practices Act		An improving trend for fish passage is clear. Past practices that constrained fish passage have been abandoned and passage will be systematically restored through the regulatory program at the time of normal structure replacement. Fish passage rules under the jurisdiction of the Department of Forestry were first established in 1973 and last modified in 1994. Prior to 1994, the design standard was for passage of adult fish upstream, without a clear requirement to maintain passage. Current rules require that all roads built since 1994 provide and maintain fish passage (adult and juvenile fish) and as culverts and other crossing structure on roads built prior to 1994 are replaced they will then be required to meet the current standards for fish passage. Landowners voluntarily increase the rate of restoring passage on roads built prior to 1994 as part of the Oregon plan. FPA monitoring shows high levels of fish passage are attained on new and replacement structures. Documentation Links Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality, ODF and DEQ 2002. http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/AllSAv1031.pdf **FPMP Technical Report #14** (pdf) - Compliance With Fish Passage and Peak Flow Requirements at Stream Crossings - Final Study Results **FPMP Technical Report #6** (pdf) - 1998 Pilot Study Results Executive Summary - 1998 Pilot Study Results (pdf), March 2000 - brief overview of the Pilot Study Results	No modifications are currently needed.	Resources and collaboration remain constraining. Current resource needs include the resources necessary to implement Forestry Program for Oregon indicator monitoring for roads and fish passage and the resources necessary to conduct more Private Forests Program compliance and effectiveness monitoring.
ODF	Private forestry component of the Oregon Plan for Salmon and Watersheds		The trend for fish passage at road crossings is clearly improving. Landowners voluntarily increase the rate of restoring passage on roads built prior to 1994 as part of the Oregon plan. FPA monitoring shows high levels of fish passage are attained on new and replacement structures. OWEB reporting indicates high levels of work on forestlands. Reporting indicates many stream crossing structures built prior to 1994, while still functioning as crossing structure, are being replaced on forestland ahead of the normal replacement schedule. This is done to restore fish passage. The number and potential impacts of existing fish barriers and blocked habitat remain unknown, however, most landowners have inventoried and prioritized barriers based upon some type of restoration schedule. Documentation Oregon Watershed Enhancement Board Watershed Restoration Inventory	Oregon Plan Measures for Private Forestlands are in the process of being updated. Changes reflect that many landowners have shifted emphasis from a 'voluntary' approach and now include legacy road work in routine road & stream crossing maintenance plans.	More resources would increase project accomplishment, education, coordination, and monitoring. For some landowners, the OWEB grant cycle is a disincentive when road work is done on an opportunistic basis. While high levels of investment in this program exist, there has been little monitoring of effectivenss.

Appendix 6. Program sufficiencies to address fish passage impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODF	State Forest Program		FPA monitoring shows high levels of fish passage are attained on new and replacement structures. Monitoring results and on-the-ground consultation with ODF stewardship foresters and ODFW habitat biologists results in a high level of success. Additionally, the state forests program provides monitoring to ensure that fish passage meets the program's performance measures. Documentation Because program standards meet or exceed those under the FPA, the documentation listed to support the sufficiency of the FPA will also support the sufficiency of the State Forests Program. Future monitoring reports produced by the State Forests Program will likely document any additional benefits produced by FMP strategies	No modifications are currently needed.	New road construction and reconstruction projects are completed to current fish passage standards. Limited funding exists for passage improvement projects not associated with timber harvest. Highest priority projects are completed first, with lower priority projects being completed as funds become available. Some districts work closely with watershed councils to attain funding for non-timber related passage improvement projects.

Appendix Table 6. (continued). Program sufficiencies to address fish passage impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODFW	Conservation Strategy for Oregon		The Oregon Conservation Strategy is a new voluntary program. As such, monitoring and evaluation will be necessary to determine the effectiveness of the program.	None at this time. The role of this new program as it pertains specifically to listed salmon and steelhead is still being defined.	Voluntary measures – no assurance that it will be implemented
ODFW	Fish Passage Program		Compliance by owners or operators is obligatory, but approval is distributed, reporting mechanisms are not in place, and compliance rates are unknown; availability of funds to implement program.	Funding for staff to perform regulatory and outreach role.	None identified.

Appendix Table 6. (continued). Program sufficiencies to address fish passage impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODFW	Fish Screening and Passage Grant Program		Actions dependent on voluntary participation in the program; availability of funds to implement projects.	Funding for outreach.	None identified.
ODFW	Lands Resources Program		Uncertain of funding status or participation by public and private entities (i.e. Riparian Lands Tax Incentive Program).	Need further promotion of existing programs by I and E, Wildlife Division, and District staff.	Funding and staff time.
ODFW	Restoration and Enhancement Program		Funding for this program is through a surcharge imposed on all sport fishing licenses and commercial salmon fishing licenses and poundage fees. As such, funding is a subject to annual variations in fish abundance, harvest rates, and license sales.	None. The Program will evaluate their ability to shift resources to priorities that emerge from recovery planning. Further changes in program scope and focus would require legislative action.	Broad legal mandates of the program limit the ability of the program to focus solely on the needs of recovery planning, variable funding due to funding mechanism.
ODFW	Salmon Trout Enhancement Program		Current staffing and the broad scope of the program limits the capacity of the program to address any single program element.	Additional funding, additional FTE.	Funding.
ODFW	Watershed Council Liaison		Currently there are only two watershed council liaison positions in ODFW, both in the North Coast Watershed District. There are no positions for other regions of Oregon.	New positions.	Funding.
ODLCD	Statewide Comprehensive Land Use Planning		The land use actions taken by local governments can supplement and support other specific restoration activities but are not sufficient in themselves to achieve restoration. Local land use actions will likely not remediate legacy conditions or significantly alter current practices, but will affect future development.	None. The statewide land use program is not intended to be sufficient to recover salmon.	Technical and planning assistance to local governments would be highly beneficial in enlisting local planning efforts in salmon recovery.

Appendix Table 6. (continued). Program sufficiencies to address fish passage impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODOT	Salmon-Fish Passage Program		ODOT's Salmon-Fish Passage Program provides adequate technical and institutional capacity to implement the program within its jurisdictional area. The program selects, designs, constructs, monitors, and documents fish passage improvement projects. The program is held in high regards and is effective for improving fish passage at known fish passage impediments; however, it lacks budgetary capacity and a clear timeline for full implementation. Currently, the ODFW statewide artificial obstruction inventory (Inventory) identifies a total of 770 priority structures owned and managed by ODOT that do not provide adequate fish passage (255 or 33%=High Priority, 167 or 22%= Medium Priority, 348 45%=Low Priority for repair). From 1997 to 2006 the ODOT program repaired 109 high priority fish passage culverts (35 high priority culverts with replacements and 74 high priority culverts with retrofits) or 42% of the ODOT managed statewide high priority culvert inventory total. ODOT high priority culvert repairs have made 370 miles of stream habitat accessible to native migratory fish. Post construction effectiveness monitoring and documentation to satisfy federal and state regulatory agencies are complete for these projects. To date, 146 high priority culverts owned and managed by ODOT continue to need repairs. We anticipate the list will grow as more culverts are inventoried. At the current rate of ~4 culvert projects repaired each year it will take approximately 36 years to repair or replace the remaining balance of high priority culverts. Similarly, there are an additional 515 (67% of the statewide total) medium and low priority culverts that will need repairs once the high priority culvert list is complete. Using the projected rate of numbers of projects completed annually (n=4) it will take significantly longer to repair the medium and low priority culverts. At the current funding and repair rate, it will take decades (over 100 years) to make the appropriate repairs to all ODOT owned and managed culverts (n=661) that currently do not provide adequate fish passage.	ODOT is working to repair as many high priority fish passage culverts as program funds will allow. Additional funding for project development and construction is necessary to decrease the timeframe this program can repair the remaining high priority culverts owned and managed by ODOT. Another key program management tool that continues to be lacking is an updated and prioritized comprehensive artificial obstruction inventory. The current Inventory is not adequate for managers to make informed planning decisions for future investments of limited fish passage funds. The Inventory aggregates artificial obstructions into three priority categories: (high, medium, and low) and some culverts known to impede fish passage are not included in the Inventory. There is no systematic standardized method or protocol for the aggregation of these culverts into the three priority categories. It would be beneficial if high priority culverts were re-evaluated and re-ranked numerically either statewide and/or basin-wide. A numeric ordering of the high priority culverts will allow ODOT and other owners and operators of substandard culvert facilities to make more informed project selection decisions based on statewide or basin-wide priorities. A comprehensive artificial obstruction inventory and robust prioritization of know fish passage impediments will provide ODOT and other owners the management tools necessary to make informed planning decisions that are consistent with salmon recovery goals.	In addition to the limitations associated with this program's budget, project development and construction costs continue to escalate. During FY 2006, construction costs increased approximately 10% due to increased costs associated with engineering design, construction materials, fuel, contractor supervision and management, etc. These increased costs continue to burden the program and result in fewer fish passage projects constructed in a given year.

Appendix Table 6. (continued). Program sufficiencies to address fish passage impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODSL	Removal-Fill Program		DSL's removal-fill permitting process requires that permitted projects maintain or restore fish passage, and encourages removal or replacement of road crossings and other passage impediments. At current staffing levels, DSL does not always have the resources to do the outreach necessary to encourage landowners to remove or replace fish passage impediments. In addition, very few projects are monitored for compliance.	Additional funding would increase the effectiveness of the program. A greater number of projects need to be monitored for compliance. Additional, permanent compliance staff are needed.	The half-time Compliance Monitoring Specialist position is funded for three years and is subject to reauthorization each year of the three -year period. The status of the position is uncertain after that time.
OWEB	Grant Program		The primary limitation to effectively addressing fish passage barriers has been lack of complete information on the nature and location of barriers in relation to productive fish habitat. OWEB has funded data gathering on a watershed scale and used information to prioritize barriers for removal. Where this information is available grants have been available to remedy high priority barriers.	Increased capital and non-capital funds	Funding

Appendix Table 7. Program sufficiencies to address instream flow impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODEQ	Non-Point Source Program		The program relies on existing state and local authorities to address non point sources of pollution. Programs to address nonpoint sources, especially in urban and agricultural areas, are relatively recent and additional time and trend monitoring is needed to document results. Additionally, while a schedule for implementation is to be identified, timing of implementation is often dependent on adequate future funding which often is not guaranteed or certain.	Adequate monitoring program needed; see other programs listed in this document for modifications needed as it relies on other existing state and local authorities for implementation. See other programs listed in this document for Modifications Needed.	See other programs listed in this document for constraints as it relies on other existing state and local authorities for implementation.
OWEB	Grant Program		Limitation on willing participation and effective grant process for purchase of water rights	Increased capital and non-capital funds	Funding

Appendix Table 7. Program sufficiencies to address instream flow impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
OWRD	Administration of Water Rights		Program design for the review of new permits is sufficient to consider needs of listed fish species. OAR Chapter 690 Division 33 lays out public interest standards for new appropriations including surface waters and hydraulically connected groundwater with the potential for substantial interference (OAR 690-009-040). Included in Division 33 are interagency consultations to determine consistency of proposed applications with the Columbia River Basin Fish and Wildlife Program. Consultation occurs with NPPC, ODFW, USFWS, NMFS, Indian tribes and appropriate local governments. Permits that cannot be conditioned to achieve consistence are presumed to impair or be detrimental to the public interest. Ongoing implementation of these OARs includes completion of documentation for each new applicant. Surface water availability is modeled for each month and evaluated at the 80% exceedance level. This information is available through the OWRD on line interactive mapping program: http://map.wrd.state.or.us/apps/wr_mapping/.	Provide flow data to support the evaluation of flows and their sufficiency during critical periods, and the adaptive management process to help assure the review and consultation process for new permits remains sufficiently protective.	Funding to support monitoring capabilities has been unstable and declining. Funding for the 2007-2009 biennium will improve statewide monitoring capabilities.
OWRD	Flow Restoration Programs		These programs are voluntary in nature. Instream leases are limited to a five year period, but leases may be renewed indefinitely. Transfers may be temporary or permanent. Allocations of conserved water are permanent. Participation in Voluntary Flow Restoration programs continues to grow. Based on the best available data, over 287 cfs have been permanently restored and 580 cfs temporarily restored instream as of 12/31/2006. Benefits realized will vary by participation levels, season, stream reach, region, and by the duration of the lease or transfer. Although the benefits of incremental improvements to flow at various times and on various life stages of listed species may not be certain, OWRD encourages incremental improvements to flow through these voluntary programs. Voluntary flow restoration programs include temporary instream leases, permanent allocations of conserved water and temporary or permanent transfers. Performance is currently available through measures tracked annually (KPM#1). Performance measures are posted online through: http://www.wrd.state.or.us/OWRD/LAW/performance.shtml Performance is tied to flows restored in key watersheds. Key watersheds, or priority water availability basin, can be found through the online interactive mapper. The performance measure is tracked by Oregon fiscal year. Graphical representation of restored flows for 2006 is available through: http://www.wrd.state.or.us/OWRD/mgmt_flow_restoration.shtml. This representation shows a positive trend in participation as outreach continues and awareness of the program grows. Accessibility of these data via the OWRD website provides documentation of program success, tools to assist willing water right holders identify needs as they relate to key watersheds and flow restoration, and will provide data important to monitoring and adaptive management.	These programs would benefit from increased education and outreach to increase participation levels, and from coordinated follow-up to encourage re-enrollment where possible. Provide available flow restoration data to support the evaluation of flows and their sufficiency during critical periods and the adaptive management process. In September 2006, funding was awarded through the National Fish and Wildlife's Columbia Transactions Program to migrate instream leasing, transfer and allocations of conserved water data to OWRD's online Water Rights Information System (WRIS). Access through this OWRD website will provide critical data for evaluating current flow restoration activities and supporting adaptive management.	Programs are constrained by limited funding and resources for outreach and education, lease/transfer follow-up and re-enrollment, and accessibility of lease/transfer data to support monitoring and evaluation of flow restoration efforts and their impacts on listed species.

Appendix Table 7 (continued). Program sufficiencies to address instream flow impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
OWRD	Lease/Transfer Water Rights Associated with CREP Program		This program works in conjunction with CREP to benefit both the restoration of riparian function and minimum flows as lands are enrolled and associated water rights are returned instream. Participation in the CREP program and instream leasing or transfer of associated water rights are voluntary. Water rights that are not leased or transferred instream may be used consistent within the terms and conditions of the water right, which may, depending on the nature of the water right, reduce potential benefits to minimum flows and riparian function.	Outreach and education programs could be improved through increased resources and greater coordination. Provide available flow restoration data to support monitoring, evaluation and the adaptive management process.	The program is dependent upon private landowner awareness of the program and voluntary participation levels. Outreach and education are constrained by available resources.
OWRD	Water Distribution and Regulation		Instream water rights do not guarantee minimum flows. Rather, they establish a quantity of water for instream beneficial use, regulated by priority date. Many instream water rights have priority dates that are junior to other water rights, reducing opportunities to regulate on their behalf. The resulting impacts to instream flows may vary by stream reach, season and priority date of the instream right. Voluntary compliance with water rights and regulations was approximately 96% statewide in 2005. However, there are over 80,000 surface water rights in Oregon. Efforts to monitor streamflow and protect instream water rights are limited by staff resources and monitoring capabilities.	Increased monitoring capabilities will support water distribution and regulation activities on behalf of water rights, including instream water rights. These additional data may also support evaluation of incremental changes to flow and the sufficiency of those flows during critical periods	Funding for staff and monitoring capabilities has been unstable and declining. The 2007-2009 budget provides funding to add monitoring and distribution capacity. The junior status of some instream water rights may limit their flow benefit in some areas. In these instances, voluntary restoration measures are key to achieving recovery goals as they relate to flow.

Appendix Table 7 (continued). Program sufficiencies to address instream flow impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
OWRD	Water Supply and Conservation Planning		Water Management and Conservation Plans are not designed to directly address flow needs for listed fish species. However, stream flows may benefit from implementation of these plans and identified conservation measures. Plan implementation may delay the need for increased municipal diversions. Stream flows may improve through implementation of agricultural plans. OWRD encourages instream protection for all or a portion of increases to stream flow brought by implementation of agricultural plans. Voluntary enrollment in the Allocation of Conserved Water Program includes incentives for agricultural water suppliers and opportunities to restore instream flows and regulate on their behalf. Potential improvements to flow are dependent upon participation and full implementation of plans. There is currently no OWRD monitoring program in place to evaluate the effectiveness of these programs. While stream flows may benefit, for the recovery of listed species, this and other plans are best considered in aggregate. Considered in aggregate, the sufficiency of some programs may change.	The Agricultural Water Management and Conservation Plan program would benefit from expanded outreach and education. OWRD is currently developing a guidebook to assist agricultural water suppliers to prepare plans that meet Oregon and Federal requirements. This guidebook will help agricultural water suppliers describe their water systems and needs, identify their sources of water, and identify ways to manage and conserve those supplies to meet present and future needs. OWRD has also received funding for the majority of requested elements of a statewide Water Supply and Conservation Initiative. This initiative will strive to address statewide water supply needs through a statewide water needs assessment, inventory of potential above and below ground water storage sites, analyses of water conservation opportunities, investigation of basin yield estimates, and match funding for community-based and regional water supply planning.	Water supply and conservation planning is constrained by limited funding and resources for outreach, education, and program development. The 2007-2009 agency budget includes the majority of funding requested for the Water Supply and Conservation Initiative.
OWRD	Water Use Measurement Strategy		Measurement of water use does not directly protect flows, but may support the evaluation of needed flows. On a statewide scale, the Water Use Measurement and Reporting position was eliminated during the last biennium and has been restored for the 2007-2009 biennium. This position is responsible for database maintenance, maintenance of on-line reporting processes and helping to assure compliance with permit reporting conditions. Efforts to promote voluntary actions may be deterred by the cost associated with installation and maintenance of measuring equipment. A cost-share program to promote voluntary water use measurement and reporting is in place, but not currently funded. Ongoing implementation of the significant diversion program is constrained by staffing levels.	No modifications to the design of this program are suggested. Restoration of the Water Use Measurement and Reporting position and funding for the existing cost-share program for voluntary water use measurement and reporting will improve ongoing implementation of the water use measurement strategy. Restoration of county-based Assistant Watermasters would further aid this strategy.	Ongoing implementation of the water use measurement strategy is constrained by available resources and staff.

Appendix Table 8. Program sufficiencies to address agriculture and forestry chemical impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODA	Agricultural Water Quality Management (SB 1010)		Basin plans and rules are reviewed biennially to determine whether the plan is sufficient to meet and address water quality standards, and modified as necessary to meet deficiencies and new requirements or information. Reviews include review of compliance actions, outreach activities, projects, and monitoring results. ODA focuses efforts and resources on areas of highest priority and program is enforced. "Compliance" is based on inspections prompted by "notification" of inappropriate occurrences; increasing complaints and notifications reflect an increased public awareness and greater number of basin rules in place. Water quality monitoring is conducted by DEQ at permanent sites. Aerial photography at 4-5 yr intervals documents riparian condition trends.	Biennial reviews will determine if modifications are needed. Given more resources (funding) implementation of on-the-ground actions, including monitoring, would be accelerated. More monitoring would provide improved documentation of program adequacy.	Landowner cooperation, capacity for outreach, changing land ownerships and new landowners knowledge of agricultural issues, perception that this is only a complaint driven process, technical assistance, adequate monitoring at meaningful scales
ODA	Pesticides		ODA is the EPA designated agency to enforce FIFRA in Oregon. This program operates under an MOA with EPA and is consistent with FIFRA requirements. There are several layers of controls to maintain responsible use of pesticides by the agricultural industry.	None, meets federal requirements	capacity for outreach
ODEQ	TMDLs		TMDLs set targets to bring waters back into compliance with water quality standards. TMDLs can address those pesticides which have numeric standards established and can address excess nutrients which can cause other water quality standard exceedences (e.g. pH, dissolved oxygen). However, very few agricultural chemicals (such as pesticides that are currently in use) have numeric water quality standards established for them and would be addressed under this program only if they exceeded a narrative standard (e.g. introducing substances in levels that are harmful to aquatic life or bioaccumulate to levels that adversely affect public health or wildlife). Additionally, the cost for monitoring many of these chemicals is high so they are not routinely monitored, unless a problem is suspected. Given the limitation in monitoring for these chemicals and in having standards established to determine impact on beneficial uses, it is uncertain if the TMDL is adequate to address the universe of Agricultural Chemicals which could cause water quality problems. That is why, since 1999, ODEQ has been using a voluntary, collaborative approach called Pesticide Stewardship Partnerships (PSPs) to identify problems and improve water quality associated with pesticide use at the local level. The PSP approach uses local expertise in combination with water quality sampling and toxicology expertise of ODEQ to encourage and support voluntary changes that cause measurable environmental improvements.	Additional staffing for this program or for an alternative program, such as the Pesticide Stewardship Partnership, to address this issue (DEQ has a budget request in for the 2007 Legislature to develop a toxics monitoring program).	Sufficient resources for monitoring to identify chemicals of concern (see Water Quality Monitoring) and for developing water quality standards to identify levels that affect beneficial uses.

Appendix Table 8. (continued). Program sufficiencies to address agriculture and forestry chemical impacts

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODEQ	TMDLs		TMDLs set targets to bring waters back into compliance with water quality standards. TMDLs can address those pesticides which have numeric standards established and can address excess nutrients which can cause other water quality standard exceedences (e.g. pH, dissolved oxygen). However, very few agricultural chemicals (such as pesticides that are currently in use) have numeric water quality standards established for them and would be addressed under this program only if they exceeded a narrative standard (e.g. introducing substances in levels that are harmful to aquatic life or bioaccumulate to levels that adversely affect public health or wildlife). Additionally, the cost for monitoring many of these chemicals is high so they are not routinely monitored, unless a problem is suspected. Given the limitation in monitoring for these chemicals and in having standards established to determine impact on beneficial uses, it is uncertain if the TMDL is adequate to address the universe of Agricultural Chemicals which could cause water quality problems. That is why, since 1999, ODEQ has been using a voluntary, collaborative approach called Pesticide Stewardship Partnerships (PSPs) to identify problems and improve water quality associated with pesticide use at the local level. The PSP approach uses local expertise in combination with water quality sampling and toxicology expertise of ODEQ to encourage and support voluntary changes that cause measurable environmental improvements.	Additional staffing for this program or for an alternative program, such as the Pesticide Stewardship Partnership, to address this issue (DEQ has a budget request in for the 2007 Legislature to develop a toxics monitoring program).	Sufficient resources for monitoring to identify chemicals of concern (see Water Quality Monitoring) and for developing water quality standards to identify levels that affect beneficial uses.
ODF	Oregon Forest Practices Act		The rules include specific best management practices (BMPs) in addition to label requirements. Spill risks are addressed and reporting of spills is required. ODF Monitoring has shown that the BMPs protect water quality from drift impacts and otherwise protect riparian vegetation. Documented adverse impacts to salmonids from forestland chemical use are not known. Documentation Links Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality, ODF and DEQ 2002. http://egov.oregon.gov/ODF/PRIVATE_FORESTS/docs/fp/AllSAv1031.pdf Chemicals/Pesticides **FPMP Technical Report #7** (pdf) - Aerial Pesticide Application Monitoring Final Report, March 2000 • Executive Summary (pdf) - shortened version of the Final Report • Eugene Water and Electric Board, Karl Morgenstern. May 2007. Case Study: Hydrologic Impacts of Forest Management on Municipal Water Supplies	None identified.	Lack of monitoring data related to post application runoff. Lack of funding and cooperation for monitoring across land uses.

Appendix 9. Program sufficiencies to address animal waste impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODA	Confined Animal Feeding Operation (CAFO)		This program limits/controls nutrient impacts on water quality for both surface and ground water. It is consistent with the federal Clean Water Act requirements for CAFOs. An Application to Register is a new requirement to meet the new federal and state requirements for permitting and concentrated animal feeding operations. A continued goal of the CAFO program is to inspect each permitted CAFO once per year. ODA also reviews, approves or rejects, Animal Waste Management Plans and specifications for animal waste control facilities to verify they have been prepared in accordance with OAR 340-051 design criteria, and USDA-NRCS conservation practice standard guidance 590 for Oregon. As a result of this increased effort, ODA has seen overall improvement in compliance on permitted operations.	None exceeds federal requirements.	Economic conditions impede the ability of operators to be more proactive in addressing fish habitat needs
ODEQ	TMDLs		TMDLs set targets to bring waters back into compliance with water quality standards, most typically targets for bacteria and nutrients that would address concerns from animal wastes. These targets include load allocations for sectors such as agriculture, forestry and urban land uses with animal wastes typically being of concern in agricultural and urban land uses. The agricultural sector has programs that address a portion of animal wastes from Confined Animal Feeding Operations (CAFO) and smaller live stock facilities through the CAFO and Agricultural Water Quality Management Plans respectively. However, programs in urban areas to address pet wastes or other sources of animal wastes (birds, etc) that get into streams via storm water runoff are relatively new, in development in many areas (especially the larger cities) or do not exist (especially in smaller cities). There is limited monitoring of the effectiveness of these programs, therefore it is uncertain if TMDLs will be adequate to address animal wastes.	None at this time.	Sufficient resources for monitoring and time to determine if programs to address storm water and agricultural water quality management are sufficient.

Appendix 10. Program sufficiencies to address human, urban, or industrial waste impacts.

Agency	Program	Sufficiency	Rationale	Modifications Needed	Constraints
ODEQ	Environmental Clean Ups		Clean up/remediation of sites addressed under this program occurs until DEQ determines that they pose no significant threat to human health or the environment and therefore require no further action. Monitoring is required to document the effectiveness of the Clean Up activity. Cleanups require documentation to assess "no further action" needed.	None	Need for a sustainable programs that matches revenues and expenses.
ODEQ	Point Source Permits		Permits are written to meet water quality standards, sources not in compliance have to come into compliance within the permit cycle (typically, 5 years). Compliance monitoring is required. Permits are reviewed and updated on at least 5-year basis or as needed, based on new requirements. Additionally, the TMDL program can require additional treatment to meet water quality based conditions. The Clean Water Act provides for citizen lawsuit as an oversight provision.	None	Number of staff is always a limitation. Funding is a blend of federal, state and fee support. Additional funding has recently been provided based on a Blue Ribbon Committee Report which recommended changes to fee structures and additional general funds.
ODEQ	TMDLs		TMDLs set targets to bring waters back into compliance with water quality standards. These targets include waste load allocations for industrial and municipal point sources and load allocation for sector specific (forestry, agricultural and urban) non-point sources of pollution. Typically municipal and industrial waste sources that discharge to waters are regulated under a permit program. Additional requirements can be established based on the TMDLs. The TMDL program is relatively new (TMDLs in Oregon have been established since the late 1980's but work is underway to develop them statewide) and has focused on a limited number of parameters (temperature, bacteria, nutrients, solids and selected toxics). It is likely that TMDLs are effective at addressing these waste sources but further documentation of the program effectiveness is needed. Also, as additional toxic pollutants are monitored and problems are identified, TMDLs or other similar types of programs will need be developed. Documentation is developed as part of the TMDL process which is often a part of the 401 certification.	None at this time	Sufficient resources for monitoring and developing TMDLs and time to determine if programs is being made.

Appendix 11. URLs of documents that further describe statewide management programs evaluated in this report.

Agency	Program	Supporting Documents - 1	Supporting Documents - 2	Supporting Documents -3
ODA	Agricultural Water Quality Management (SB 1010)	http://www.oregon.gov/ODA/NRD/water_quality_front.shtml		
ODA	Confined Animal Feeding Operation (CAFO)	http://www.oregon.gov/ODA/NRD/cafo_front.shtml		
ODA	Pesticides	http://www.oregon.gov/ODA/PEST/index.shtml		
ODA	Soil and Water Conservation Districts	http://www.oregon.gov/ODA/SWCD/index.shtml		
ODA	Weed Control and Invasive Species	http://www.oregon.gov/ODA/PLANT/index.shtml		
ODEQ	401 Dredge & Fill Certifications	http://www.deq.state.or.us/wq/401Cert/401CertHome.htm		
ODEQ	401 Hydroelectric Recertification	http://www.deq.state.or.us/wq/401Cert/401CertHome.htm		
ODEQ	Environmental Clean Ups	http://www.deq.state.or.us/lq/cu/		
ODEQ	Non-Point Source Program	http://www.deq.state.or.us/wq/nonpoint/nonpoint.htm	http://www.deq.state.or.us/wq/loans/srfloans.htm	
ODEQ	Point Source Permits	http://www.deq.state.or.us/wq/wqpermit/stminfo.htm		
ODEQ	Storm Water Permits	http://www.deq.state.or.us/wq/stormwater/swphome.htm		
ODEQ	TMDLs	http://www.deq.state.or.us/WQ/TMDLs/TMDLs.htm	http://www.deq.state.or.us/wq/pubs/factsheets/community/pesticide.pdf	
ODEQ	Water Quality Standards	http://www.deq.state.or.us/wq/standards/wqstdshome.htm		
ODF	Fire Program	http://www.odf.state.or.us/pcf/fp/fpa.asp?id=401010207		
ODF	Oregon Forest Practices Act	http://www.odf.state.or.us/pcf/fp/fpa.asp?id=401010207		
ODF	Private forestry component of the Oregon Plan for Salmon and Watersheds	http://www.oregon-plan.org/OPSW/cohoproject/PDFs/8-4-06.ODF.Coho.Plan.actions.pdf		
ODF	State Forest Program	http://www.odf.state.or.us/pcf/fp/fpa.asp?id=401010207	http://egov.oregon.gov/ODF/STATE_FORESTS/nwfmp.shtml	http://egov.oregon.gov/ODF/STATE_FORESTS/Roads_Manual.shtml
ODFW	Conservation Strategy for Oregon	http://www.dfw.state.or.us/conservationstrategy/		
ODFW	Fish Passage Program	www.dfw.state.or.us/fish/passage/		

Agency	Program	Supporting Documents - 1	Supporting Documents - 2	Supporting Documents -3
ODFW	Fish Screening and Passage Grant Program	www.dfw.state.or.us/ODFWhtml/InfoCntrFish/screen_passage_grants.htm		
ODFW	Lands Resources Program	http://www.dfw.state.or.us/lands/		
ODFW	Restoration and Enhancement Program	http://www.dfw.state.or.us/fish/RE/		
ODFW	Salmon Trout Enhancement Program	http://www.dfw.state.or.us/STEP/		
ODSL	Removal-Fill Program	http://www.oregon.gov/DSL/PERMITS/r-fintro.shtml		
ODSL	Voluntary Restoration Initiative	http://www.oregonstatelands.us/DSL/WETLAND/wetland_restoration.shtml		
OWEB	CREP Program	Oregon Watershed Enhancement Board		
OWEB	Grant Program	Oregon Watershed Enhancement Board		
OWRD	Administration of Water Rights	http://www.wrd.state.or.us/OWRD/PUBS/aquabook_newrights.shtml	http://www1.wrd.state.or.us/pdfs/reports/SW02-002.pdf	
OWRD	Flow Restoration Programs	http://www.wrd.state.or.us/OWRD/mgmt_opsw.shtml	http://www.wrd.state.or.us/OWRD/mgmt.shtml	http://www.oregon.gov/OWRD/mgmt.shtml-Water_Conservation
OWRD	Lease/Transfer Water Rights Associated with CREP Program	http://www.oregon.gov/OWRD/mgmt_leases.shtml	http://www1.wrd.state.or.us/pdfs/CREP_letter.pdf	
OWRD	Water Distribution and Regulation	http://www.wrd.state.or.us/OWRD/mgmt.shtml	http://www.wrd.state.or.us/OWRD/PUBS/aquabook_enforcing.shtml	
OWRD	Water Supply and Conservation Planning	http://www.wrd.state.or.us/OWRD/mgmt.shtml		
OWRD	Water Use Measurement Strategy	http://www.wrd.state.or.us/OWRD/WR/water_use_report.shtml		

Appendix G

Culverts which Need to be Improved or Replaced Within Oregon Mid-C Steelhead Populations

Number and location of culverts which need to be improved or replaced within steelhead populations in Fifteenmile Creek and the Deschutes River Basin. This is an incomplete list as comprehensive culvert inventories have not been conducted.

Fifteenmile Creek Total Culverts = 6				
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
	Ramsey Cr (FS 4450 Rd)	USFS	1	H
	Fifteenmile Cr (FS 44 Rd)	USFS	1	H
	Threemile (Hwys I-84 & 197)	ODOT	2	M
	Chenowith Cr (Bridge at Hwy 30)	ODOT	1	M
	NF Mill Cr (RM 6.0)	Wasco Co	1	U
Deschutes River Eastside Total Culverts = 2				
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
	Mud Springs Cr (RR culvert in Sec. 15 above Gateway)	Jefferson City	1	H
	Hay Cr (new channel near mouth)	Private	1	H
Deschutes River Westside Total Culverts = TBD				
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
	Warm Springs River		TBD	H
	Beaver Cr		TBD	H
	Shitike Cr		TBD	H
	Oak Cr		TBD	
	Metolius River		TBD	

Number and location of culverts which need to be improved or replaced within steelhead populations in the John Day Basin.

Lower Mainstem John Day River Total Culverts = 84				
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Bridge Cr	Bridge Cr	Wheeler	1	H
Bridge Cr	Carroll Cr	Wheeler	1	L
Bridge Cr	Keyes Cr	Wheeler	1	L
Bridge Cr	Mud Cr	Wheeler	1	L
Bridge Cr	Myers Cyn	Wheeler	1	L
Bridge Cr	O'Kelly Cr	Wheeler	1	L
Bridge Cr	Un Cr	ODOT	2	L
Bridge Cr	Un Cr	Wheeler	1	L
Bridge Cr	West Br	Wheeler	1	L
Bridge Cr	West Br	Wheeler	1	M
Butte Cr	Butte Cr	ODOT	1	M
Butte Cr	Butte Cr	Wheeler	3	M
Butte Cr	Cottonwood Cr	ODOT	1	M
Grass Valley Cyn	Demoss Cyn	ODOT	1	L
Grass Valley Cyn	Grass Valley Cyn	Sherman	4	L
Lower JDR Kahler Cr	Alder Cr	Wheeler	3	M
Lower JDR Kahler Cr	Button Hollow	Wheeler	1	L
Lower JDR Kahler Cr	Horseshoe Cr	Wheeler	1	L
Lower JDR Kahler Cr	Indian Hollow	Wheeler	1	L
Lower JDR Kahler Cr	Kahler Cr	Wheeler	1	L
Lower JDR Kahler Cr	Parrish Cr	Wheeler	1	L
Lower JDR Kahler Cr	Parrish Cr	Wheeler	1	M
Lower JDR Kahler Cr	Un Cr	Wheeler	1	L
Lower JDR Muddy Cr	Current Cr	WASC	1	L
Lower JDR Muddy Cr	Cove Cr	ODOT	1	L
Lower JDR Muddy Cr	Indian Cyn	ODOT	1	L
Lower JDR Muddy Cr	John Day Gl	Wheeler	1	L
Lower JDR Muddy Cr	Lone Pine Cr	Wheeler	1	L
Lower JDR Muddy Cr	Pine Cr	Wheeler	1	L
Lower JDR Muddy Cr	Un Cr	ODOT	2	L
Lower JDR Service Cr	Dry Gulch	ODOT	1	L
Lower JDR Service Cr	Dry Hollow	Wheeler	1	L
Lower JDR Service Cr	Girds Cr	ODOT	3	L
Lower JDR Service Cr	Girds Cr	Wheeler	2	L
Lower JDR Service Cr	Little Service Cr	ODOT	1	L
Lower JDR Service Cr	Rowe Cr	Wheeler	3	L
Lower JDR Service Cr	Rowe Cr	Wheeler	2	M
Rock Cr	Birch Cr	Wheeler	1	L
Rock Cr	Fred Cr	Wheeler	1	L
Rock Cr	Juniper Gulch	ODOT	1	L
Rock Cr	Pine Hollow	Wheeler	1	M
Rock Cr	Rock Cr	ODOT	1	L
Rock Cr	Un Cr	Wheeler	1	L
Thirtymile Cr	Thirtymile Cr	Wheeler	4	M
Lower JDR Kahler Cr	East Bologna Cr	USDA-FS	1	H
5th Field HUC	Stream	Ownership	Number of Culverts	Priority

Lower JDR Kahler Cr	East Bologna trib	USDA-FS	1	H
Lower JDR Kahler Cr	Davis Cr	USDA-FS	3	H
Lower JDR Kahler Cr	Henry Cr	USDA-FS	1	H
Lower JDR Kahler Cr	Henry Cr trib	USDA-FS	1	H
Lower JDR Kahler Cr	Burnt Cabin Cr	USDA-FS	2	H
Lower JDR Kahler Cr	Tamarack Cr	USDA-FS	2	H
Lower JDR Kahler Cr	Tamarack Cr trib	USDA-FS	1	H
Lower JDR Kahler Cr	Alder Cr	USDA-FS	1	H
Lower JDR Kahler Cr	Alder Cr trib	USDA-FS	4	H
Lower JDR Kahler Cr	Wheeler Cr	USDA-FS	2	H
Rock Cr	Stahl Cyn	USDA-FS	2	H
Rock Cr	Wineland Cr	USDA-FS	1	H

North Fork John Day River
Total Culverts = 200

5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Lower Camas Cr	Wilkins Cr	ODOT	1	M
Lower NF JDR	Deer Cr	Grant	1	L
NF JDR Potamus Cr	W Fk	ODOT	2	M
Upper NFJD	Davis Cr	USDA-FS	2	H
Upper NFJD	Trout Cr trib	USDA-FS	2	H
Upper NFJD	Crane Cr	USDA-FS	1	H
Granite Cr	Ten Cent Cr	USDA-FS	1	H
Granite Cr	W Ten Cent Cr	USDA-FS	2	H
Granite Cr	Lightning Cr	USDA-FS	1	H
Granite Cr	Lake Cr	USDA-FS	2	H
Granite Cr	Rabbit Cr trib	USDA-FS	1	H
Granite Cr	Lost Cr	USDA-FS	1	H
Granite Cr	Granite Cr	USDA-FS	1	H
Big Cr	Winom Cr	USDA-FS	1	H
Big Cr	Meadow Cr trib	USDA-FS	3	H
Big Cr	Squaw Cr	USDA-FS	1	H
Big Cr	White Cr	USDA-FS	1	H
Big Cr	Martin Cr	USDA-FS	2	H
Big Cr	SF Meadow Cr trib	USDA-FS	2	H
Big Cr	Big Cr	USDA-FS	1	H
Big Cr	White Cr	USDA-FS	1	H
Big Cr	Meadow Cr	USDA-FS	2	H
Big Cr	Texas Bar Cr trib	USDA-FS	3	H
Big Cr	Texas Bar Cr	USDA-FS	5	H
Big Cr	Juniper Cr	USDA-FS	1	H
Desolation Cr	NF Desolation Cr	USDA-FS	3	H
Desolation Cr	Sponge Cr	USDA-FS	1	H
Desolation Cr	Howard Cr	USDA-FS	2	H
Desolation Cr	SF Desolation Cr	USDA-FS	1	H
Desolation Cr	Skinner Cr	USDA-FS	1	H
Desolation Cr	NF Desolation Cr trib	USDA-FS	1	H
Desolation Cr	Battle Cr	USDA-FS	1	H
Desolation Cr	Little Kelsay Cr	USDA-FS	2	H
Desolation Cr	Bruin Cr	USDA-FS	1	H
Desolation Cr	Beeman Cr	USDA-FS	4	H
5th Field HUC	Stream	Ownership	Number of Culverts	Priority

Desolation Cr	Junkens Cr	USDA-FS	6	H
Desolation Cr	Desolation Cr trib	USDA-FS	1	H
Desolation Cr	Park Cr	USDA-FS	1	H
Upper Camas Cr	Neeves Cr	USDA-FS	1	H
Upper Camas Cr	SF Cable Cr	USDA-FS	2	H
Upper Camas Cr	NF Cable Cr	USDA-FS	1	H
Upper Camas Cr	Bear Wallow Cr	USDA-FS	3	H
Upper Camas Cr	Bowman Cr	USDA-FS	4	H
Upper Camas Cr	Bowman Cr trib	USDA-FS	1	H
Upper Camas Cr	Trib to Bowman Cr	USDA-FS	1	H
Upper Camas Cr	Frazier Cr	USDA-FS	3	H
Upper Camas Cr	Frazier Cr trib	USDA-FS	1	H
Upper Camas Cr	Butcher Knife Cr	USDA-FS	1	H
Upper Camas Cr	Camas Cr trib	USDA-FS	5	H
Upper Camas Cr	Camas Cr	USDA-FS	2	H
Upper Camas Cr	Dry Camas Cr	USDA-FS	1	H
Upper Camas Cr	Hidaway Cr	USDA-FS	1	H
Lower Camas Cr	Silver Cr	USDA-FS	1	H
Lower Camas Cr	Dry Five Mile Cr	USDA-FS	1	H
Lower Camas Cr	Taylor Cr	USDA-FS	2	H
Lower Camas Cr	Taylor Cr trib	USDA-FS	1	H
Lower Camas Cr	Tribble Cr	USDA-FS	1	H
Lower Camas Cr	Turpentine Cr	USDA-FS	1	H
Lower Camas Cr	Five Mile Cr	USDA-FS	1	H
Lower Camas Cr	Morsay Cr	USDA-FS	2	H
Lower Camas Cr	Sugarbowl Cr	USDA-FS	2	H
Lower Camas Cr	Silver Cr trib	USDA-FS	1	H
Lower Camas Cr	No Name 2	USDA-FS	1	H
Lower Camas Cr	Deer Lick Cr trib	USDA-FS	4	H
NF JDR Potamus Cr	Butcher Bill Cr	USDA-FS	1	H
NF JDR Potamus Cr	Ditch Cr	USDA-FS	3	H
NF JDR Potamus Cr	Ditch Cr trib	USDA-FS	2	H
NF JDR Potamus Cr	Horse Heaven Cr	USDA-FS	2	H
NF JDR Potamus Cr	Jones Canyon	USDA-FS	1	H
NF JDR Potamus Cr	Long Canyon	USDA-FS	1	H
NF JDR Potamus Cr	Mallory Cr	USDA-FS	3	H
NF JDR Potamus Cr	Martin Cr	USDA-FS	1	H
NF JDR Potamus Cr	Matlock Cr	USDA-FS	1	H
NF JDR Potamus Cr	Matlock Cr trib	USDA-FS	1	H
NF JDR Potamus Cr	Rush Cr trib	USDA-FS	1	H
NF JDR Potamus Cr	Thompson Cr	USDA-FS	3	H
NF JDR Potamus Cr	Thompson Cr trib	USDA-FS	2	H
NF JDR Potamus Cr	Smith Cr	USDA-FS	1	H
NF JDR Potamus Cr	WF Meadow Brook	USDA-FS	7	H
NF JDR Potamus Cr	EF Meadow Brook	USDA-FS	1	H
NF JDR Potamus Cr	Brush Cr	USDA-FS	1	H
NF JDR Potamus Cr	WF Meadow Brook trib	USDA-FS	1	H
NF JDR Potamus Cr	Pole Cr	USDA-FS	2	H
NF JDR Potamus Cr	Potamus Cr	USDA-FS	2	H
NF JDR Potamus Cr	Potamus Cr trib	USDA-FS	1	H
NF JDR Potamus Cr	Gilbert Cr trib	USDA-FS	3	H
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
NF JDR Potamus Cr	Little Potamus Cr	USDA-FS	1	H

NF JDR Potamus Cr	Little Potamus Cr trib	USDA-FS	2	H
NF JDR Potamus Cr	Deep Cr	USDA-FS	1	H
NF JDR Potamus Cr	Gilbert Cr	USDA-FS	3	H
NF JDR Potamus Cr	Ellis Cr	USDA-FS	1	H
Wall Cr	Dry Swale Cr	USDA-FS	2	H
Wall Cr	Swale Cr	USDA-FS	3	H
Wall Cr	Bear Cr trib	USDA-FS	1	H
Wall Cr	Alder Cr trib	USDA-FS	4	H
Wall Cr	Skookum Cr	USDA-FS	1	H
Wall Cr	Swale Cr trib	USDA-FS	2	H
Wall Cr	Hog Cr	USDA-FS	1	H
Wall Cr	Hog Cr trib	USDA-FS	1	H
Wall Cr	Keeney Cr	USDA-FS	1	H
Wall Cr	Little Wall Cr	USDA-FS	2	H
Wall Cr	Three Trough Cr trib	USDA-FS	1	H
Wall Cr	Rough Cyn	USDA-FS	1	H
Wall Cr	Cat Cyn	USDA-FS	2	H
Wall Cr	Indian Cr	USDA-FS	3	H
Wall Cr	Dark Cyn Cr	USDA-FS	1	H
Wall Cr	Lost Cyn trib	USDA-FS	1	H
Wall Cr	Willow Spring Cr	USDA-FS	1	H
Wall Cr	Big Wall Cr	USDA-FS	2	H
Wall Cr	Grassy Butte Cr	USDA-FS	1	H
Wall Cr	SF Big Wall Cr	USDA-FS	1	H
Wall Cr	Keating Cr	USDA-FS	1	H
Wall Cr	SF Wall Cr	USDA-FS	1	H
Wall Cr	Colvin Cr	USDA-FS	2	H
Wall Cr	Big Wall Cr trib	USDA-FS	1	H
Wall Cr	Wilson Cr trib	USDA-FS	2	H
Wall Cr	Wilson Cr	USDA-FS	1	H

Middle Fork John Day River
Total Culverts = 242

5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Upper MF JDR	Bridge Cr	ODOT	5	L
Upper MF JDR	Bridge Cr	ODOT	7	H
Upper MF JDR	Mill Cr	ODOT	1	L
Upper MF JDR	North Fk	ODOT	1	H
Lower MF JDR	Barnes Cr	ODOT	1	L
Lower MF JDR	Eightmile Cr	Grant	1	M
Lower MF JDR	Sixmile Cr	Grant	1	M
Lower MF JDR	Twelvemile Cr	Grant	1	M
MF JDR	Clear Cr	USDA-FS	1	H
Upper MF JDR	Bridge Cr	USDA-FS	3	G
Upper MF JDR	Bridge Cr	USDA-FS	20	H
Upper MF JDR	Bridge Cr	Private	1	H
Upper MF JDR	Bridge Cr trib	USDA-FS	3	H
Upper MF JDR	Clear Cr	USDA-FS	1	H
Upper MF JDR	Crawford Cr	USDA-FS	5	U
Upper MF JDR	Crawford Cr	USDA-FS	5	H
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Upper MF JDR	Dry Fork Clear Cr	USDA-FS	1	U

Upper MF JDR	Dry Fork Clear Cr	USDA-FS	5	H
Upper MF JDR	Fly Cr	USDA-FS	1	H
Upper MF JDR	Frosty Gulch	USDA-FS	3	H
Upper MF JDR	Idaho Cr	USDA-FS	1	U
Upper MF JDR	Idaho Cr	USDA-FS	1	H
Upper MF JDR	Little Phipps Cr	USDA-FS	2	U
Upper MF JDR	Little Phipps Cr	USDA-FS	1	H
Upper MF JDR	Lunch Cr	USDA-FS	2	H
Upper MF JDR	NF Bridge Cr	USDA-FS	1	U
Upper MF JDR	NF Bridge Cr	USDA-FS	9	H
Upper MF JDR	Olmstead Cr	USDA-FS	1	U
Upper MF JDR	Olmstead Cr	USDA-FS	2	H
Upper MF JDR	Papoose Cr	USDA-FS	2	H
Upper MF JDR	Phipps Cr	USDA-FS	2	H
Upper MF JDR	Road Cr	USDA-FS	2	H
Upper MF JDR	Rock Spring	USDA-FS	1	H
Upper MF JDR	Savage Cr	USDA-FS	1	H
Upper MF JDR	Sawtooth Cr	USDA-FS	1	H
Upper MF JDR	SF Bridge Cr	USDA-FS	2	H
Upper MF JDR	Sixteen Gulch	USDA-FS	1	H
Upper MF JDR	Squaw Cr	USDA-FS	5	U
Upper MF JDR	Squaw Cr	USDA-FS	6	H
Upper MF JDR	Summit Cr	USDA-FS	1	U
Upper MF JDR	Summit Cr	USDA-FS	11	H
Camp Cr	Bear Cr	USDA-FS	1	H
Camp Cr	Beaver Cr	USDA-FS	2	H
Camp Cr	Big Boulder Cr	USDA-FS	3	H
Camp Cr	Big Rock Cr	USDA-FS	1	H
Camp Cr	Blue Gulch	USDA-FS	2	H
Camp Cr	Butte Cr	USDA-FS	3	H
Camp Cr	Camp Cr	USDA-FS	1	U
Camp Cr	Camp Cr	USDA-FS	1	H
Camp Cr	Camp Cr trib	USDA-FS	4	H
Camp Cr	Caribou Cr	USDA-FS	2	U
Camp Cr	Cottonwood Cr	USDA-FS	2	U
Camp Cr	Cottonwood Cr	USDA-FS	2	H
Camp Cr	Cougar Cr	USDA-FS	1	U
Camp Cr	Cougar Cr	USDA-FS	2	H
Camp Cr	Coxie Cr	USDA-FS	1	H
Camp Cr	Coyote Cr	USDA-FS	1	U
Camp Cr	Coyote Cr	USDA-FS	2	H
Camp Cr	Deadwood Cr	USDA-FS	1	U
Camp Cr	Deadwood Cr	USDA-FS	4	H
Camp Cr	Deep Cr	USDA-FS	2	U
Camp Cr	Deep Cr	USDA-FS	3	H
Camp Cr	Dry Cr (Sunshine Cr)	USDA-FS	1	H
Camp Cr	E Fk Big Cr	USDA-FS	4	H
Camp Cr	E Fk Sunshine Cr	USDA-FS	1	H
Camp Cr	E Little Boulder Cr	USDA-FS	1	H
Camp Cr	Eagle Cr	USDA-FS	1	H
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Camp Cr	East Windlass Cr	USDA-FS	1	H
Camp Cr	Elk Cr	USDA-FS	1	H
Camp Cr	Granite Boulder Cr	USDA-FS	4	H
Camp Cr	Hawkins Cr	USDA-FS	1	H

Camp Cr	Lick Cr	USDA-FS	2	U
Camp Cr	Lick Cr	USDA-FS	2	H
Camp Cr	Little Boulder Cr	USDA-FS	5	H
Camp Cr	Little Trail Cr	USDA-FS	1	H
Camp Cr	Lost Cr	USDA-FS	3	H
Camp Cr	Lost Cr or Pizer Cr	USDA-FS	1	H
Camp Cr	MF Sunshine Cr	USDA-FS	1	H
Camp Cr	Morning Cr	USDA-FS	1	H
Camp Cr	Mosquito Cr	USDA-FS	1	H
Camp Cr	Murdock Cr	USDA-FS	3	H
Camp Cr	Myrtle Cr	USDA-FS	1	U
Camp Cr	Myrtle Cr	USDA-FS	1	H
Camp Cr	N Fk Elk Cr	USDA-FS	2	H
Camp Cr	N Fk Camp Cr	USDA-FS	1	U
Camp Cr	N Fk Camp Cr	USDA-FS	1	H
Camp Cr	Placer Gulch	USDA-FS	1	H
Camp Cr	Porky Cr	USDA-FS	2	H
Camp Cr	Ragged Cr	USDA-FS	2	H
Camp Cr	Ruby Cr	USDA-FS	1	U
Camp Cr	Sulpher Cr 2	USDA-FS	1	H
Camp Cr	Sunshine Cr	USDA-FS	2	H
Camp Cr	Swamp Gulch	USDA-FS	1	H
Camp Cr	Tin Cup Cr	USDA-FS	3	H
Camp Cr	Vincent Cr	USDA-FS	1	U
Camp Cr	Vincent Cr	USDA-FS	4	H
Camp Cr	Vinegar Cr	USDA-FS	2	H
Camp Cr	Vinegar Cr trib	USDA-FS	1	H
Camp Cr	W Fk Lick Cr	USDA-FS	1	H
Camp Cr	W Fk Lick Cr	USDA-FS	1	U
Camp Cr	Whiskey Cr	USDA-FS	3	H
Camp Cr	Windlass Cr	USDA-FS	2	H
Camp Cr	Wray Cr	USDA-FS	2	H
Big Cr	Slide Cr	USDA-FS	2	H
Long Cr	Dry Fk Clear Cr	USDA-FS	1	H
Long Cr	Jugow Cr	USDA-FS	1	H
Long Cr	Long Cr	USDA-FS	1	H
Long Cr	Long Cr	USDA-FS	2	U
Long Cr	S Fk Long Cr	USDA-FS	1	U

South Fork John Day River
Total Culverts = 74

5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Lower SF JDR	Oliver Cr	Grant	1	L
Lower SF JDR	Smoky Cr	Grant	1	M
Middle SF JDR	Pine Cr	Grant	1	L
Middle SF JDR	Poison Cr	Grant	1	L
Middle SF JDR	Un Cr	Grant	1	L
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Upper SF JDR	Antelope Cr	Grant	1	L
Upper SF JDR	Lewis Cr	Grant	2	L
Upper SF JDR	Lewis Cr	Grant	1	M
Upper SF JDR	Venator Cr	Grant	1	M
Upper SF JDR	Cougar Cr	USDA-FS	1	H
Murderers Cr	Basin Cr	USDA-FS	2	H

Murderers Cr	Buck Cr	USDA-FS	2	H
Murderers Cr	Charlie Mack Cr	USDA-FS	1	H
Murderers Cr	Corral Cr	USDA-FS	2	U
Murderers Cr	Corral Cr	USDA-FS	3	H
Murderers Cr	Crazy Cr	USDA-FS	1	H
Murderers Cr	Dans Cr	USDA-FS	3	H
Murderers Cr	Dead Injun Cr	USDA-FS	6	H
Murderers Cr	Deer Cr	USDA-FS	7	H
Murderers Cr	Duncan Cr	USDA-FS	2	H
Murderers Cr	E Fk Deer Cr	USDA-FS	1	H
Murderers Cr	Lemon Cr	USDA-FS	3	H
Murderers Cr	Murderers Cr	USDA-FS	5	H
Murderers Cr	Murderers Cr	USDA-FS	1	U
Murderers Cr	Orange Cr	USDA-FS	1	H
Murderers Cr	Oregon Mine Cr	USDA-FS	2	H
Murderers Cr	SF Deer Cr	USDA-FS	1	U
Murderers Cr	SF Murderers Cr	USDA-FS	1	U
Murderers Cr	SF Murderers Cr	USDA-FS	2	H
Murderers Cr	Sugar Cr	USDA-FS	1	H
Murderers Cr	Tex Cr	USDA-FS	6	H
Murderers Cr	Thorn Cr	USDA-FS	8	H
Murderers Cr	Vester Cr	USDA-FS	1	H
Murderers Cr	White Cr	USDA-FS	1	H

Upper Mainstem John Day River
Total Culverts = 120

5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Beech Cr	Beech Cr	ODOT	5	H
Beech Cr	Beech Cr	Grant	1	H
Beech Cr	Cottonwood Cr	ODOT	1	H
Beech Cr	McClellen Cr	Grant	1	M
Beech Cr	Thompson Cr	Grant	1	L
Beech Cr	Un Cr	Grant	1	L
Beech Cr	Warm Springs Cr	ODOT	1	L
Big Cr	Deep Cr	Grant	1	L
Canyon Cr	Alder Gl	Grant	1	L
Canyon Cr	East Gl Cr	Grant	1	L
Canyon Cr	Sheep Gulch	ODOT	1	L
Canyon Cr	Vance Cr	ODOT	1	L
Cottonwood Cr	Wiley Cr	ODOT	1	H
Laycock Cr	Coal Pit Cr	Grant	1	L
Laycock Cr	Harper Cr	Grant	1	M
Laycock Cr	Ingle Cr	Grant	1	M
Laycock Cr	Luce Cr	ODOT	1	L
Laycock Cr	Luce Cr	Grant	1	L
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Mountain Cr	Marshall Cr	ODOT	1	L
Mountain Cr	Thorn Hollow	ODOT	1	L
Mountain Cr	Tubb Cr	ODOT	1	L
Mountain Cr	Un Cr	ODOT	2	L
Mountain Cr	Whiskey Cr	ODOT	1	L
Strawberry Cr	Cow Cr	Grant	1	L
Strawberry Cr	Dixie Cr	Grant	1	M

Strawberry Cr	Dog Cr	Grant	3	L
Strawberry Cr	Dog Cr	Grant	2	M
Strawberry Cr	Grub Cr	Grant	5	L
Strawberry Cr	Gwyn Cr	Grant	1	L
Strawberry Cr	Hall Cr	ODOT	1	L
Strawberry Cr	Little Indian Cr	Grant	2	L
Strawberry Cr	Little Pine Cr	ODOT	1	H
Strawberry Cr	Little Pine Cr	Grant	2	L
Strawberry Cr	Pine Cr	ODOT	1	L
Strawberry Cr	Pine Cr	Grant	2	L
Strawberry Cr	Slyfe Cr	Grant	1	L
Strawberry Cr	Spring Cr	Grant	1	L
Strawberry Cr	Squaw Cr	Grant	1	L
Strawberry Cr	Un Cr	Grant	1	L
Strawberry Cr	Un Cr	ODOT	2	L
Strawberry Cr	West Fork	Grant	1	M
Upper JDR	Dans Cr	Grant	1	M
Upper JDR	Graham Cr	Grant	1	L
Upper JDR	Jeff Davis Cr	Grant	1	L
Upper JDR	John Day R	Grant	1	H
Upper JDR	John Day R	Grant	1	M
Upper JDR	Un Cr	Grant	3	L
Upper JDR	Winegar Gl	Grant	1	L
Cottonwood Cr	Day Cr	USDA-FS	1	H
Upper JDR	Call Cr	USDA-FS	1	H
Upper JDR	Dans Cr	USDA-FS	1	H
Upper JDR	Deardorff Cr	USDA-FS	1	H
Upper JDR	Isham Cr	USDA-FS	1	H
Upper JDR	John Day R	USDA-FS	5	H
Upper JDR	Mossy Gulch	USDA-FS	2	H
Upper JDR	NF Reynolds Cr	USDA-FS	3	H
Upper JDR	Reynolds Cr	USDA-FS	2	H
Upper JDR	Roberts Cr	USDA-FS	1	U
Upper JDR	SF Deardorff Cr	USDA-FS	1	H
Canyon Cr	Canyon Cr	USDA-FS	3	H
Canyon Cr	Crazy Cr	USDA-FS	2	H
Canyon Cr	MF Canyon Cr	USDA-FS	1	H
Strawberry Cr	Dixie Cr	USDA-FS	2	H
Strawberry Cr	Hall Cr	USDA-FS	3	H
Strawberry Cr	John Day R	USDA-FS	1	H
Strawberry Cr	Onion Cr	USDA-FS	1	H
Strawberry Cr	Strawberry Cr	USDA-FS	1	H
Strawberry Cr	W Fk Little Indian Cr	USDA-FS	1	H
Beech Cr	Bear Cr	USDA-FS	1	H
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
Beech Cr	Bear Cr trib	USDA-FS	1	H
Beech Cr	E Fk Beech Cr	USDA-FS	1	U
Beech Cr	E Fk Beech Cr	USDA-FS	1	H
Beech Cr	Lake Cr	USDA-FS	1	H
Beech Cr	Tinker Cr	USDA-FS	1	H
Laycock Cr	Riely Cr	USDA-FS	2	H
Laycock Cr	Umatilla Cr	USDA-FS	1	H
Fields Cr	Belshaw Cr	USDA-FS	1	U
Fields Cr	Buck Cabin Cr	USDA-FS	2	H
Fields Cr	Fields Cr	USDA-FS	1	U

Fields Cr	Fields Cr	USDA-FS	6	H
Fields Cr	Last Cr	USDA-FS	1	H

Number and location of culverts which need to be improved or replaced within steelhead populations in the Umatilla River. This is an incomplete list as comprehensive culvert inventories have not been conducted.

Umatilla River Total Culverts = 25				
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
	Johnson Cr. (Butter Trib-RM 0.3)		1	M
	Bridge Cr (West Birch-RM 2.0)		1	H
	Jungle/Windy Spr (Pearson-RM 0.1)		1	L
	Whitman Spr (RM 0.1)		1	L
	Red Elk Can. (RM 0.2)		1	L
	Minthorn Spr (RM 0.1)		1	L
	Un Trib to SF Umatilla at RM 1.5 (RM 0.1)		1	M
	Un Trib to Umatilla R. at RM 81.2 (RM 0.1)		1	L
	Twomile Cr (RM 1.250		1	L
	Butter Cr	USDA-FS	6	H
	Willow Cr	USDA-FS	6	H
	Umatilla R.	USDA-FS	2	H
	Umatilla R.	USDA-FS	1	H
	Meacham Cr	USDA-FS	1	H

Number and location of culverts which need to be improved or replaced within steelhead populations in the Walla Walla River. This is an incomplete list as comprehensive culvert inventories have not been conducted.

Walla Walla River Total Culverts = 22				
5th Field HUC	Stream	Ownership	Number of Culverts	Priority
	Pine Cr at Johnson Rd		1	M
	Pine Cr at Hwy 11		1	M
	Pine Cr at Pine Cr Rd		1	M
	Dry Cr (Upper Dry Cr Rd)		1	M
	Little Dry Cr (Winn Rd)		1	M
	Dr Cr (upstream of Sapolil Rd)		1	M
	East Little Walla Walla (Locust Rd)		1	M
	East Little Walla Walla (Appleton Rd)		1	M
	East Little Walla Walla (Crockett Rd)		1	M
	East Little Walla Walla (Ballou Rd)		1	M
	East Little Walla Walla (Stateline Rd)		1	M
	West Little Walla Walla (Winesap Rd)		1	M
	West Little Walla Walla (Appleton Rd)		1	M
	West Little Walla Walla (Sunquist Rd)		1	M
	West Little Walla Walla (Stateline Rd)		1	M
	Middle Branch Mud Cr (Triangle Rd)		1	M
	Middle Branch Mud Cr (County Rd 332)		2	M
	Titus Cr (at mouth)		1	M
	Birch Cr (Powerline Rd)		1	H
	Couse Cr (gravel pit entrance RM 1.1)		1	H
	Cup Gulch (NF Walla Walla River Rd)		1	M

APPENDIX H

Management Actions Effectiveness and Model Data and Assumptions

Management Actions Effectiveness and Model Data and Assumptions

This appendix is presented in two parts. Part 1 provides action effectiveness assumptions and related factor scalars used in analyzing actions. Part 2 provides a series of graphic reports that give additional information about the predicted outcomes of the subbasin habitat scenarios analyzed in Section 10. These graphic reports are extracted from output produced by EDT.

Part 1: Action Effectiveness Assumptions

Part 1 consists of fifteen tables that describe action effectiveness assumptions and related factor scalars used in analyzing the subbasin habitat actions, as well as, the life stage specific survival rate assumptions applied to the component life stages from smolt leaving the subbasin to adult return to the subbasin. See Section 10 of the report for a full description of how the assumptions and scalars are applied. The tables are:

H-1. List of habitat actions analyzed within the subbasins.
H-2. Subbasins where habitat actions were designated to be applied.
H-3. Action effectiveness assumptions and levels applied in analysis.
H-4. Action implementation intensity assumptions and levels applied in analysis.
H-5. Action effectiveness lag scalars applied to habitat actions.
H-6. Action implementation schedule scalars at 25 years applied to habitat actions.
H-7. Action implementation schedule scalars at 100 years applied to habitat actions.
H-8. Attribute scalars applied to habitat actions.
H-9. Definitions of freshwater habitat attributes shown in Table H-8.
H-10. Out-of-basin survival rates in AHA modeling for baseline (B), current (C) and prospective future action scenarios for Fifteenmile Creek winter steelhead.
H-11. Out-of-basin survival rates in AHA modeling for baseline (B), current (C) and prospective future action scenarios for Deschutes River Eastside and Westside summer steelhead.
H-12. Out-of-basin survival rates in AHA modeling for baseline (B), current (C) and prospective future action scenarios for John Day River summer steelhead populations.
H-13. Out-of-basin survival rates in AHA modeling for baseline (B), current (C) and prospective future action scenarios for Umatilla River summer steelhead.
H-14. Out-of-basin survival rates in AHA modeling for baseline (B), current (C) and prospective future action scenarios for Walla Walla River summer steelhead.

Tributary Habitat Action Effectiveness Assumptions
Tributary habitat actions, locations, intensity, time scalars, and effectiveness scalars are presented in tables H-1 – H-9.

Table H-1. Habitat actions analyzed within Oregon subbasins for their effects on population performance of Mid-Columbia steelhead. See Section 9 for further descriptive details of actions.

(Table H-1. List of actions.)

Strategy	Action	Description
1. Protect/conserve ecological processes		
	Acquisition/conservation	Protect the highest quality habitats through acquisition or conservation measures.
	Protect rare functioning habitats	Protect and conserve rare and unique functioning habitats.
	BMPs to conserve eco processes	Consistently apply Best Management Practices (BMPs) and existing laws to protect and conserve natural ecological processes.
	Cooperative Agreements	Adopt and manage Cooperative Agreements.
	Special mgmt designations	Special management designations on public lands.
	Increase wild-scenic status	Designate additional wilderness and wild and scenic status.
	Protect access to key habitats	Protect access to key habitats.
	Outreach to users and managers	Conduct outreach to resource users and managers (resulting in improved management practices).
	Public lands protection	Continue existing protections and/or increase protection of Federal lands; implement Forest Practices Act and PACFISH/INFISH.
	Waterway setbacks	Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function.
	Enforce floodplain regs	Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues.
	Natural Area Overlay Zone	Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance.
	Legislate priority areas	Explore opportunities to incorporate priority areas into state legislation (resulting in improved management practices).
2. Restore fish passage blocked/impaired by barriers		
	Barrier removal	Replace barriers blocking passage including dams, road culverts and irrigation structures.
	Add irrigation screening	Provide screening at 100% of irrigation diversions.
	Pelton Round Butte passage	Restore passage at Pelton Round Butte Complex in the Deschutes river system.
	Upgrade irrigation screening	Replace screens that do not meet criteria.
	Reduce push up dams	Remove or minimize use of push up dams.
	Fish ladder construction	Construct ladders over existing permanent concrete or earth fill dams, or remove the barrier.
	Maintain passage facilities	Operate and maintain fish passage facilities to meet criteria.
3. Restore floodplain connectivity and function		
	Reconnect floodplain	Reconnect floodplains to channels.
	Reconnect side channels	Reconnect side channels and off-channel habitats to stream channels.

(Table H-1. List of actions.)

Strategy	Action	Description
	Reintroduce beaver	Reintroduce beaver in suitable habitat.
	Restore wet meadows	Restore wet meadows.
	Dike removal	Remove dikes and levies.
	Manage beavers	Manage beaver population and educate public.
4. Restore degraded channel structure/complexity		
	Restore natural channel form	Restore natural channel form.
	Large wood enhancement	Increase role and abundance of wood and large organic debris in streambeds.
	Add structure	Increase instream habitat through manual placement of structures.
	Stabilize streambanks	Stabilize streambanks.
	Build pool weirs	Construct rock and log weirs to create pool habitats or elevate incised channels.
	BMP bridge maintenance	Implement bridge maintenance BMPs.
	LWD education	Educate landowners on importance of large woody debris (LWD)(resulting in improved LWD management practices).
5. Restore riparian condition and LWD recruitment		
	Restore riparian communities	Restore natural riparian communities.
	Improve grazing practices	Develop grazing strategies that promote riparian recovery (and implement).
	Eradicate invasive plants	Eradicate invasive plant species from riparian areas.
	Fencing	Install fencing to exclude livestock from riparian areas.
	Off-stream livestock watering	Install off-stream livestock watering.
	Riparian plantings	Plant riparian vegetation where appropriate.
	Increase riparian shading	Plant riparian vegetation where appropriate.
	No cultivation buffer zones	Develop no-cultivation riparian buffer on agricultural lands and establish riparian setbacks for structures in areas where activities could upset riparian function.
	Maintain RHCAs on USFS lands	Maintain existing widths of riparian habitat conservation areas (RHCAs) on USFS lands.
	Remove riparian roads	Close, remove, and restore riparian road prisms.
	Riparian protection	Protect high quality riparian habitats and unstable areas.
6. Restore natural hydrograph components		
	Ag water conservation	Implement agricultural water conservation measures.
	Improve irrigation conveyance	Improve irrigation conveyance and efficiency.
	Orchard Ridge/Wolf Run	Finish piping Orchard Ridge and Wolf Run diversions.
	Urban conservation	Implement urban conservation measures.
	Convert water rights	Lease or purchase water rights and convert to instream.
	Regulate water withdrawals	Monitor/regulate water withdrawals.
	Water retention structures	Water retention structures.

(Table H-1. List of actions.)

Strategy	Action	Description
	Increase pool habitat (beav ponds)	Increase pool habitat (beaver ponds).
	Floodplain aquifer recharge	Floodplain aquifer recharge.
	H2O rights transfer downstream	Downstream water rights transfers.
	Water storage investigate	Investigate feasibility of water storage or exchange to improve instream flows for steelhead (assumed to improve water conservation/management).
	No new H2O appropriation	Close areas to appropriation of new water uses.
	Criteria for new H2O appropriation	Set criteria to protect flows for fish habitat from new appropriations.
	Enhance hyporheic flows	Enhance hyporheic flows and spring inputs.
	Recharge shallow aquifers	Implement shallow aquifer recharge.
	Aquifer storage & recovery	Aquifer storage and recovery.
	Umatilla Basin Project Phase I and II	Implement Umatilla Basin Project Phase I and II. The Umatilla Basin Project Act, passed by Congress in 1988, allows irrigators to exchange Umatilla River water for Columbia River water. Two phases of the Act have been completed and a third phase has been proposed. This action that addresses Phases 1 and II would continue the operation of the project under these phases.
	Umatilla Basin Project Phase III	Implement Umatilla Basin Project Phase III. This action would provide a substantial increase of Umatilla River water to remain instream compared to the action associated with just Phases I and II.
	ISWRs	File for additional instream water rights (ISWRs) (assumed to be successful). While instream water rights have been established on many of the important spawning and rearing stream in the Umatilla and Walla Walla subbasins, some have not. Where important spawning and rearing streams have not been protected by instream water rights, instream flow studies would be conducted and instream water rights applied for (it is assumed that some would be granted).
7. Improve degraded water quality		
	Manage irrigation return flow	Manage irrigation return flow to reduce extreme stream temperatures.
	Measures to improve DO	Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels.
	Reduce chemical pollution	Reduce chemical pollution inputs.
	Implement Ag WQP	Implement an Agricultural Water Quality Plan. (Oregon's agricultural water quality plans created by Senate Bill 1010 are locally-driven area-wide plans addressing agricultural water quality problems while providing a regulatory backstop. They provide landowner flexibility in solving local water quality issues. Enforcement is not a primary method for assuring success, although compliance is a component. The premise is that when landowners are given opportunities to address issues, and offered technical assistance, success will generally follow. This approach has proven successful in some subbasins (see http://www.oregon.gov/ODA/news/0407aq.shtml)

(Table H-1. List of actions.)

Strategy	Action	Description
	TMDL monitoring	Continue TMDL monitoring. A TMDL is the calculated pollutant amount that a waterbody can receive and still meet Oregon water quality standards. The process for building a plan to improve water quality starts when a waterbody appears on DEQ's 303(d) list, which lists waterbodies that do not meet water quality standards. Federal law requires that streams, rivers, lakes and estuaries that appear on the 303(d) list be managed to meet state water quality standards. Plans to restore streams and rivers to water quality standards are developed by governmental agencies in cooperation with landowners. Agriculture issues are addressed by the Oregon Department of Agriculture working with landowners (under Senate Bill 1010 -- see Ag Water Quality plan above). Private and state forest issues are addressed the Oregon Department of Forestry (through the Forest Practices Act). Federal agencies (such the U.S. Forest Service or the Bureau of Land Management) have responsibility for federal lands. Urban and rural areas not covered by other state or federal agencies are addressed by cities and counties, working with local watershed councils.
	Reduce mine discharge toxicants	Address contamination from mine related discharge.
	Animal feeding BMPs	Apply BMPs to animal feeding operations.
	Point source pollution controls	Address point sources of water pollution.
	H2O quality mgmt plans	Implement water quality management plans (it is not specified that these are Agricultural Water Quality Plans but it is presumed; this is kept separate from the Agricultural Water Quality Plan due to uncertainty in the type of plan and in implementation).
	Pest mgmt plans for fruit growers	Implement pest management plans for fruit growers. Note: it is assumed that this action would entail an integrated pest management program comparable to the action below specified as "Implement IFPnet plans" to be implemented in Fifteenmile subbasin.
	Municipal stormwater mgmt	Improve municipal stormwater management and treatment.
	Waterway alteration permitting	Permit waterway alteration activities and enforce rules. "Waterway alteration" means any action that will result in excavation, dredging, filling, rechannelization, construction, or any other type of modification of an aquatic habitat area occupied by ESA-listed species that will affect the conservation value of that habitat. This action is only relevant for analysis if other actions are to be analyzed that consist of waterway alternations, in which case, the action would serve as a measure of protection. Permitting can require compensation or mitigation but would be assumed to only offset any take.
	Permitting for H2O quality activities	Permit and enforce actions that could affect water quality. This action is aimed at improving permitting/enforcement of land/water use activities that could impact water quality. This action is only relevant in the present analysis if other actions (such as build-out) are to be analyzed that would degrade water quality, in which case the action would serve protect.

(Table H-1. List of actions.)

Strategy	Action	Description
8. Restore upland processes to reduce erosion		
	Convert till farming	Provide incentives to farmers to convert to no till farming; target achieving 95% conversion to no till farming in specified areas.
	Convert to perennial crops	Convert to perennial crops/vegetation.
	Implement IFPnet plans	The project encourages growers in Wasco County (Fifteenmile Creek subbasin) to reduce the use of broad-spectrum OP pesticides and replace them with new generation, less toxic pesticides. It utilizes methods referred to as integrated fruit management. Using a web-based interface, IFP project participants use the degree-day models and data to make better decisions and precise timed application of new generation, less toxic pesticides. Note: action should more correctly be placed under Strategy 7.
	Improve/remove forest roads	Upgrade or remove problem forest roads.
	Reforest/fuels management	Promote fuel management.
	Upland demo projects	Initiate demonstration projects (assumed to be instrumental in improving upland lands management).
	BMPS to reduce soil erosion	Employ BMPs to minimize unnatural rates of erosion.
	Remove junipers	Remove junipers.
	Restore native upland plants	Restore native upland plants.
	Invasive plant mgmt & junipers	Manage vegetation, including juniper removal.
	BMPs on land uses	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices.
	CREP & CCRP buffers	Implement Continuous Conservation Reserve Program and Conservation Reserve Enhancement Program (CREP and CCRP) buffers; voluntary, non-competitive, programs for agricultural landowners providing financial incentives.
	Outreach to upland users	Conduct outreach to resource users and managers (assumed to lead to improvements in uplands lands management).

Table H-2. Subbasins where habitat actions were designated to be applied. See Section 9 for further descriptive details of actions.

(Table H-2. Subbasins where actions were applied.)

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
1. Protect/conserve ecological processes						
	Acquisition/conservation	X	X	X	X	X
	Protect rare functioning habitats	X	X	X		X
	BMPs to conserve eco processes	X	X	X	X	X
	Cooperative Agreements		X	X		
	Special mgmt designations		X	X		
	Increase wild-scenic status			X		
	Protect access to key habitats			X		
	Outreach to users and managers			X		
	Public lands protection				X	X
	Waterway setbacks				X	X
	Enforce floodplain regs				X	X
	Natural Area Overlay Zone				X	X
	Legislate priority areas				X	X
2. Restore fish passage blocked/impaired by barriers						
	Barrier removal	X	X	X	X	X
	Add irrigation screening		X	X	X	X
	Pelton Round Butte passage		X			
	Upgrade irrigation screening		X	X	X	X
	Reduce push up dams			X		
	Fish ladder construction		(addressed with barrier removal)			
	Maintain passage facilities	X	X	X	X	X
3. Restore floodplain connectivity and function						
	Reconnect floodplain	X	X	X	X	X
	Reconnect side channels	X	X	X	X	X
	Reintroduce beaver	X	X	X		
	Restore wet meadows			X		
	Dike removal				X	X
	Manage beavers					X

(Table H-2. Subbasins where actions were applied.)

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
4. Restore degraded channel structure/complexity						
	Restore natural channel form	X	X	X	X	X
	Large wood enhancement	X	X	X	X	X
	Add structure	X	X			
	Stabilize streambanks	X	X	X	X	X
	Build pool weirs				X	X
	BMP bridge maintenance					X
	LWD education					X
5. Restore riparian condition and LWD recruitment						
	Restore riparian communities	X	X	X	X	X
	Improve grazing practices	X	X	X	X	X
	Eradicate invasive plants	X	X			
	Fencing	X	X		X	X
	Off-stream livestock watering	X	X			
	Riparian plantings	X				
	Increase riparian shading		X	X		
	No cultivation buffer zones				X	X
	Maintain RHCAs on USFS lands				X	
	Remove riparian roads				X	X
	Riparian protection					X
6. Restore natural hydrograph components						
	Ag water conservation	X	X	X	X	
	Improve irrigation conveyance	X	X	X		X
	Orchard Ridge/Wolf Run	X				
	Urban conservation	X				
	Convert water rights	X	X	X	X	X
	Regulate water withdrawals	X	X	X	X	X
	Water retention structures		X			
	Increase pool habitat (beaver ponds)			X		
	Floodplain aquifer recharge			X		
	H2O rights transfer downstream				X	X
	Water storage investigate					X

(Table H-2. Subbasins where actions were applied.)

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
	No new H2O appropriation					X
	Criteria for new H2O appropriation					X
	Enhance hyporheic flows					X
	Recharge shallow aquifers					X
	Aquifer storage & recovery					X
	Umatilla Basin Project Phase I and II				X	
	Umatilla Basin Project Phase III				X	
	ISWRs				X	X
7. Improve degraded water quality						
	Manage irrigation return flow	X	X	X		
	Measures to improve DO	X	X			
	Reduce chemical pollution	X	X	X		
	Implement Ag WQP	X	X			
	TMDL monitoring		X	X		
	Reduce mine discharge toxicants			X		
	Animal feeding BMPs			X		
	Point source pollution controls				X	X
	H2O quality mgmt plans				X	X
	Pest mgmt plans for fruit growers					X
	Municipal stormwater mgmt					X
	Waterway alteration permitting					X
	Permitting for H2O quality activities					X
8. Restore upland processes to reduce erosion						
	Convert till farming	X	X	X		
	Convert to perennial crops	X	X			
	Implement IFPnet plans	X				
	Improve/remove forest roads	X	X	X	X	X
	Reforest/fuels management	X	X			
	Upland demo projects	X		X	X	X
	BMPS to reduce soil erosion	X	X			
	Remove junipers		X			
	Restore native upland plants		X	X	X	X

(Table H-2. Subbasins where actions were applied.)

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
	Invasive plant mgmt & junipers			X		
	BMPs on land uses			X	X	X
	CREP & CCRP buffers					X
	Outreach to upland users					X

Table H-3A and B. Action effectiveness assumptions and levels applied in analysis (A) and corresponding effectiveness values assigned to each action with rationale/comments (B). See Section 10 for how effectiveness values were applied.

Table H-3A. Action effectiveness levels.

Effectiveness level	Definition	Effectiveness
1	Very high	0.80
2	Moderately high	0.56
3	Moderate	0.32
4	Low	0.08
5	Negligible	0.01
6	No effect	0.00

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
1. Protect/conserve ecological processes			
	Acquisition/conservation	0.80	Land set-asides can be expected to return to their natural condition over time, passively restoring adjacent aquatic habitats. Maximum effectiveness should be very high unless constraints have been imposed by previous land uses. Such an effectiveness level assumes a sufficient scale of implementation to affect an entire stream reach. The action would also have very high effectiveness for protection purposes.
	Protect rare functioning habitats	0.08	It is assumed that rare functioning habitats are very limited in size and distribution. Therefore, actions to restore such habitats would likely be limited by being able to fully address the suite of conditions that create such habitats, providing only low effectiveness. Protection of such habitats against further degradation would be more effective than in restoring them (protection against further degradation would be analyzed if build-out actions were to be addressed).
	BMPs to conserve eco processes	0.32	Best management practices to conserve ecological processes within watersheds are generally known and further improvements in understanding can be expected in the near future as there are on-going studies to address this issue. These practices would be aimed at root causes of how ecological processes have been altered by land use (Beechie and Bolton 1999). Bolton et al. (2005) suggest that such practices will be beneficial in first conserving, then restoring natural processes, especially in watersheds where urbanization is not increasing. A moderate effectiveness is reasonable to expect.
	Cooperative Agreements	0.08	Cooperative Agreements involving voluntary agreements between private land owners and governments can address a variety of issues. Lack of specificity here is assumed to provide a generally low potential for effectiveness that addressing wide scale issues.
	Special mgmt designations	0.32	Special management designations can specify types of management that can occur on lands, here taken to mean federal lands (no actions in the Oregon plan call for special designations on state lands). Such designations can specify areas of critical environmental concern or other types of designations, and limit types of management practices allowed. Moderate effectiveness is assumed because the type of special management designation has not been specified.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Increase wild-scenic status	0.32	Wild and scenic status limits types of management practices allowed but not all activities. This status would provide for passive restoration within the areas specified. A moderate level of effectiveness is assumed given that various types of management practices can still occur.
	Protect access to key habitats	--	Issue is covered completely by other actions as this action was described; not given an effectiveness value here.
	Outreach to users and managers	0.08	Modest results as a separate action are expected from this because education can be expected to accompany other line item actions. Low effectiveness assumed.
	Public lands protection	0.32	This action continues previously enacted protection policies/practices on public lands. The action can be expected to have high value to protect against further degradation. For restoration purposes, the action would be passive, which would continue to maintain or improve conditions on certain public lands; moderate effectiveness assumed.
	Waterway setbacks	0.56	This action would establish setbacks (like buffers) along selected waterways to minimize active land uses such as agriculture and forest harvest. When enforced, setbacks can be particularly effective at protecting and restoring riparian and floodplain processes. Moderately high effectiveness is assumed.
	Enforce floodplain regs	0.32	Action calls for making floodplain regulations more effective than they are currently and providing for enforcement. Action is assumed to be only moderately effective because of the on-going need that will occur to maintain some level of protection against flooding and stream channel instability in areas where roads, bridges, and private lands exist.
	Natural Area Overlay Zone	0.08	This provision of the Umatilla County Development Ordinance was developed to protect and preserve ecologically and scientifically significant natural areas; it was developed as an add on, being added to other provisions that addressed protection of riparian zones and stream setbacks. It was assigned a low effectiveness value because it is an add on to other provisions that already address similar issues. It would be given greater values for protection benefits, but here would serve mainly as a passive restoration action.
	Legislate priority areas	0.01	This action would be mainly investigative, considering new legislation to identify and protect priority habitat issues. As such it is considered here to have a negligible effect because of uncertainty it what it would address; many other avenues are considered to be in place or proposed for action to address such issues.
2. Restore fish passage blocked/impaired by barriers			
	Barrier removal	>0.80	Where barriers are identified in the actions to be fixed or removed, it is assumed that passage will be provided in full.
	Add irrigation screening	0.80	Adding irrigation screening where absent will almost always correct any screening related mortalities at the immediate site. Very high effectiveness is assumed.
	Pelton Round Butte passage	0.75-0.99	Don Ratliff of PGE provided passage values to be applied: 75% for downstream juvenile passage and 99% for upstream adult passage.
	Upgrade irrigation screening	0.80	Where need for upgrading irrigation screening exists, it is assumed these screens would be outdated. It is assumed that such upgrading would be highly effective.
	Reduce push up dams	0.56	Concerted efforts to reduce or eliminate push up dams can be assumed to be moderately high if measures are so enacted. Even with such measures, their effectiveness would be limited because of likely difficulties in fully enforcing or requiring their elimination.
	Fish ladder construction	--	This measure is addressed as part of barrier removal in the analysis.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Maintain passage facilities	0.00	Maintenance of fish passage facilities is assumed to occur in the analysis. A separate action that specifies maintenance is not considered to add to effectiveness.
3. Restore floodplain connectivity and function			
	Reconnect floodplain	0.32	Measures to reconnect floodplain channels can be limited by how channels and floodplains have been altered by past land use practices. Channel incision, for example, can be difficult to reverse. A moderate level of effectiveness is assumed.
	Reconnect side channels	0.32	Measures to reconnect side channels can be limited by how channels and floodplains have been altered by past land use practices. Channel incision, for example, can be difficult to reverse. A moderate level of effectiveness is assumed.
	Reintroduce beaver	0.56	Beavers historically were a significant factor in the creation and maintenance of channel structure and off-channel habitats in some types of streams (Naiman et al. 1988). When reintroduced, and managed, they can be an effective way of restoring some types of habitats and natural channel form. Moderately high effectiveness is assumed.
	Restore wet meadows	0.32	Wet meadows are a key element in some streams for helping to maintain flows and in providing some aspects of off-channel habitats in some seasons. A moderate level of effectiveness is assumed where such sites can be targeted for restoration, where land use practices can be effectively controlled. Effectiveness is not regarded as high because of constraining factors in the drainage that would tend to limit the degree that completely restored channel function could occur where impacts have been high in the past.
	Dike removal	0.56	This action would have a comparable effectiveness to waterway setbacks. When implemented, dike removal can be particularly effective at restoring riparian and floodplain processes. Moderately high effectiveness is assumed. Limitations would exist in watersheds where development has occurred.
	Manage beavers	0.56	Beavers historically were a significant factor in the creation and maintenance of channel structure and off-channel habitats in some types of streams (Naiman et al. 1988). When reintroduced, and managed, they can be an effective way of restoring some types of habitats and natural channel form. Moderately high effectiveness is assumed.
4. Restore degraded channel structure/complexity			
	Restore natural channel form	0.32	Measures to natural channel form can be limited by how channels and floodplains have been altered by past land use practices. Channel incision, for example, can be difficult to reverse. A moderate level of effectiveness is assumed.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Large wood enhancement	0.32	Enhancement of large wood can have a significant effect on channel form and function, in both small and large streams. The ability of large wood to so function depends in part on its abundance, size, and type of wood, and on the size and geomorphology of the stream system (Maser and Sedell 1994; Collins et al. 2003; Fox 2001; Fox 2003). When wood can be completely restored to its pre-development level, it can very effectively restore channel conditions, though not necessarily to pre-development conditions due to other operating factors (such as change in hydrograph, sediment loading, floodplain development, etc.). However, wood enhancement is often limited by availability, size classes available, ability to locate properly, and other logistical difficulties. Additionally, wood enhancement is usually not maintained, hence it can be naturally depleted without future recruitment. A moderate level of effectiveness is assumed.
	Add structure	0.32	Similar limitations exist in adding structure of various kinds to streams as for large wood enhancement. A moderate level of effectiveness is assumed.
	Stabilize streambanks	0.32	Stream bank stabilization is affected by various factors besides just what can be affected at specific sites at the time of implementation. Success is often determined by factors occurring at the landscape level. Well designed stabilization projects can be quite effective, however. Overall, a moderate level of effectiveness is assumed.
	Build pool weirs	0.08	Success of actions that construct pool weirs are often strongly affected by factors outside the control of managers, such as those occurring at the landscape scale (Beechie and Bolton 1999). Such structures often fail. Well designed structures do sometimes persist and can promote creation of long-term habitats that are desired. Overall, a low level of effectiveness would be more normal; a low level is assumed here.
	BMP bridge maintenance	0.01	BMPs to maintain bridges, their footings, and adjacent stream banks are needed to reduce effects of bridges on surrounding aquatic habitats. Overall, a negligible effectiveness is assumed, however, due the limited scope of their effect on stream habitat.
	LWD education	0.32	Maintenance and protection of large wood recruited to streams is often highly dependent on the level of scavenging that occurs for wood from active flood channels by local residents. In some areas, wood recruited to streams is very rapidly removed by local residents. Reasons for removal are use for firewood and a belief that wood removal will promote stream stability. Well designed, concerted efforts to educate local residents about the importance of maintaining in-stream wood is assumed to be moderately effective--such effectiveness could only be achieved by a long-term commitment to address the issue.\
5. Restore riparian condition and LWD recruitment			
	Restore riparian communities	0.80	It is assumed here that restoring riparian communities over a substantially long reach can be very effective when various conditions can be controlled (such as controlling grazing----Platts 1991) and where natural watershed processes are largely intact (such as having a normative or natural hydrograph--Naiman et al. 2005). Intensive efforts to restore riparian conditions can produce significant progress towards predevelopment conditions in relatively few years in some ecoregions (Opperman and Merenlender 2004). This level of effectiveness is assumed to be applicable to an eastside ecoregion. With an intensive application to restore conditions, and in conjunction with activities that simultaneously restore the natural hydrograph, effectiveness is assumed to be very high.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Improve grazing practices	0.32	Grazing practices can be managed to reduce impacts on sediment loading, temperature, stream bank and channel stability, and other aspects of stream habitat (Elmore 1992). A moderate level of effectiveness is assumed for a comprehensive program of improving grazing practices.
	Eradicate invasive plants	0.08	Invasive plants are widespread in all Northwest watersheds. Some species are changing the structure of stream channels due to their prolific growth. An intensive effort to control invasives would have very limited success due to their extensive distributions and productivity. A low level of effectiveness is assumed.
	Fencing	0.80	Enclosures, such as by fencing, can have significant success in restoring riparian areas within eastside streams (Opperman and Merenlender 2004). A similar level of effectiveness is assumed here as described for "Restore riparian communities", i.e., very high effectiveness.
	Off-stream livestock watering	0.32	Off-stream livestock watering can significantly aid in reducing grazing pressure immediately adjacent to streams. A moderate level of effectiveness is assumed with a concerted effort to achieve the objective.
	Riparian plantings	0.32	Riparian plantings can accelerate and promote restoration of riparian areas. However, they would have limited success without on-going efforts to control grazing. A moderate level of effectiveness is assumed.
	Increase riparian shading	0.32	This action is like that of "Riparian plantings." A moderate level of effectiveness is assumed.
	No cultivation buffer zones	0.56	In areas where farming occurs, no cultivation buffer zones will be effective at re-establishing riparian communities. A moderately high level of effectiveness is assumed where such restrictions are maintained; some level of impact could remain present due to other activities besides cultivation.
	Maintain RHCAs on USFS lands	0.32	The action would maintain existing widths on USFW riparian habitat conservation areas, which provide some level of protection while allowing for grazing and other management activities. The level of effectiveness for this action is considered moderate, as certain types of impacts would persist, but conditions in the riparian area would be improved over existing conditions.
	Remove riparian roads	0.56	This action would remove riparian riparian roads, which are highly intrusive to riparian corridors, adding sediment, intercepting and diverting groundwater seeps, and impeding other floodplain functions. Effectiveness at restoring certain conditions within the floodplain corridor of this action is deemed moderately high.
	Riparian protection	0.32	This action would afford protection to some types of riparian areas and any unstable areas associated with them. The action would also provide passive restoration, which would help recover any degraded aspects of the riparian area. It is considered to be moderately effective as it is unclear what types of activities might continue to be allowed.
6. Restore natural hydrograph components			
	Ag water conservation	0.32	This action would implement certain conservation measures on agricultural uses of water to the extent that opportunities exist. In areas where such opportunities do exist, a moderate level of effectiveness is assumed. Actual realized effectiveness would be limited by opportunities.
	Improve irrigation conveyance	0.56	This action would target irrigation conveyance systems to improve their efficiency and reduce water wastage.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Orchard Ridge/Wolf Run	0.32	Within the Fifteenmile subbasin, Orchard Ridge Ditch and Wolf Run Ditch have a combined total of about 12 miles of unpiped ditches with significant water loss. Piping both of these ditches would save approximately 1.5 cfs each, which, according to the Oregon State "Allocation of Conserved Water Statute", could be allocated partially to instream flow and partially to the water rights holders (Fifteenmile subbasin plan). Because of this sharing between providing for instream use, together with providing an allocation to users, a moderate level of effectiveness was assigned.
	Urban conservation	0.08	Urban water users are considered a relatively small water use in the subbasins of concern, except in some specific areas. Also, continued growth in these areas will limit effectiveness of conservation measures. A low effectiveness is assigned.
	Convert water rights	0.32	Under an aggressive program to lease or purchase rights and convert the water to flow downstream, a moderate level of effectiveness is assumed. Realized effectiveness would be a function of opportunity (seen in action intensity).
	Regulate water withdrawals	0.32	This action would implement a more accountable form of monitoring and regulation to better ensure compliance on water withdrawals. A moderate level of effectiveness is assumed.
	Water retention structures	0.08	This action is only applicable to some areas in the Deschutes subbasin. It would place water retention structures in key tributaries to augment flow during low flow periods. The type of structures and their operation remain uncertain and undefined. A low effectiveness is assumed.
	Increase pool habitat (beaver ponds)	0.32	This action would seek to increase pool area habitat (thereby augmenting flow during low flow periods) by facilitating creation of beaver ponds. In areas suitable for such habitat creation, the action should be quite effective. A moderate level of effectiveness is assumed where opportunities exist (specified by the intensity assumption). This action would only be implemented in some areas of the John Day system.
	Floodplain aquifer recharge	0.32	This action would seek to recharge the floodplain aquifer at specific sites and thereby increase flows downstream during periods of low flow. Plan specifics, though not described, suggest a high level of certainty. The level of effectiveness was assumed to be moderate, but realized effectiveness would be limited to opportunities and willingness of land owners.
	H2O rights transfer downstream	0.32	This action would seek to transfer water rights downstream, presumably creating more instream flow within reaches affected by those existing rights. Realized benefits downstream would depend on issues existing in those areas. A moderate level of effectiveness is assumed, but realized benefits would depend on opportunities and arrangements of water rights along the stream corridor.
	Water storage investigate	0.01	This action would be mainly investigative, considering ways of learning new ways of storing water and improving overall efficiency of use in the subbasin. Due to uncertainties, a negligible effectiveness is assumed.
	No new H2O appropriation	0.00	This action would close areas to new water appropriation. While it would protect against increases in water use, it would have no effect on current use.
	Criteria for new H2O appropriation	0.32	This action would set updated criteria to protect flows for fish habitat from new appropriations and it is assumed that it could have a carryover effect to save more water for instream uses than currently allowed. Where opportunities exist, it is assumed to have a moderate effectiveness (though a low intensity of likely opportunities for water savings would make realized effectiveness very small).

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Enhance hyporheic flows	0.08	This action would seek to enhance hyporheic flows and flows in springs. Uncertainty in action details result in this action being assigned a low effectiveness. These types of projects are highly experimental in nature with uncertain expected results.
	Recharge shallow aquifers	0.08	This action would seek to recharge shallow aquifers. Uncertainty in action details result in this action being assigned a low effectiveness. Plan specifics state that certainty of outcome is undetermined. These types of projects are highly experimental in nature with uncertain expected results.
	Aquifer storage & recovery	0.08	This action would seek to improve aquifer storage and recharge. Plan specifics state that the effectiveness of the action is "unknown." A low effectiveness is assumed.
	Umatilla Basin Project Phase I and II	0.32	Phase I and II of the Umatilla Basin Project are currently meeting certain critical flow needs in the mainstem of the Umatilla River. The program would be continued under this action. Target flows for the Umatilla River mainstem were established as part of the Basin Project to meet essential life history needs of Chinook and coho salmon and steelhead. The Basin Project as currently implemented does not provide adequate water to meet the target flows throughout all of the times needed by these species, and fails to provide any flow mitigation for a significant length of the river in July and August. It is assumed that project effectiveness under this action is moderate (see additional details spelled out in the Umatilla subbasin plan).
	Umatilla Basin Project Phase III	0.32	Phase I and II of the Umatilla Basin Project are currently meeting certain critical flow needs in the mainstem of the Umatilla River. Target flows for the Umatilla River mainstem were established as part of the Basin Project to meet essential life history needs of Chinook and coho salmon and steelhead. Phases 1 and II do not provide adequate water to meet the target flows throughout all of the times needed by these species, and fails to provide any flow mitigation for a significant length of the river in July and August. Phase III would keep a substantial amount of Umatilla River water instream. This action is assigned a moderate level of effectiveness (combined with Phase I and II action, it would result in an overall effectiveness of moderately high).
	ISWRs	0.32	While instream water rights (ISWRs) have been established on many of the important spawning and rearing stream in the Umatilla and Walla Walla subbasins, some have not. Where important spawning and rearing streams have not been protected by instream water rights, appropriate instream flow studies would be conducted and instream water rights applied for. It is assumed that a moderate level of effectiveness for this action would result.
7. Improve degraded water quality			
	Manage irrigation return flow	0.08	This action would consist of measures to reduce irrigation return flow to streams--or improve its quality--to reduce extreme water temperatures. This action is assigned a low effectiveness due to strong influence of other factors affecting high water temperatures in the subbasins of interest. Types of measures to minimize return flows are listed as use of cover crops, straw mulch, and grass filter strips (Middle Deschutes Local Advisory Committee 2006).
	Measures to improve DO	0.08	This action would consist of measures to reduce unnatural factors that affect dissolved oxygen levels in the streams of interest. This action is assigned a low effectiveness due to strong influence of other factors affecting nutrient loading, flow levels, water temperatures and related oxygen levels in the subbasins of interest.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Reduce chemical pollution	0.32	This action addresses chemical (e.g., pesticides) pollution related to agricultural practices in the Fifteenmile, Deschutes, and John Day subbasins. Actions specified in the plan state that levels reaching streams are generally unknown and need to be determined. The plan also states that certainty of outcome of treatment is moderate to high (depending on subbasin). Action effectiveness assigned here is moderate. Realized effectiveness would be determined by the intensity of application of the action (but given uncertainties in where and when the problem is occurring, a low intensity is applied.
	Implement Ag WQP	0.32	This action calls for implementation of an agricultural water quality plan in the Fifteenmile and Deschutes subbasins. The plans are locally-driven area-wide plans that address agricultural water quality problems while providing a regulatory backstop. The plans provide landowner flexibility in solving local water quality issues. Enforcement is not a primary method for assuring success, although compliance is a component. The planning teams responsible for Section 9 (this plan) expect certainty of outcome to be high in both basins and suggest a significant degree of success. A moderate level of effectiveness is assumed here in both subbasins (with a high level of intensity of application).
	TMDL monitoring	0.08	This action utilizes TMDL monitoring to help trigger the formulation of management plans to address specific water quality issues. All of the issues that might trigger a TMDL response management plan are addressed through other actions in this suite of actions. Therefore, an effectiveness of low is assigned to this action as an add-on effect, presuming that TMDL monitoring will aid in making other actions more effective.
	Reduce mine discharge toxicants	0.32	This action addresses past mining in the John Day subbasin. The action is described by the planning team as having a high certainty of outcome, although it would be contingent upon adequate maintenance of needed components. The action would require long term implementation. An effectiveness of moderate is assumed given uncertainties associated with long-term maintenance.
	Animal feeding BMPs	0.56	This action is aimed at a small number of feedlots in the John Day subbasin, which operate in conjunction with use of riverside meadows for winter feeding operations. The plan (Section 9) states that certainty of outcome, once a treatment has been agreed upon, is high. A moderately high effectiveness level is assigned to the action.
	Point source pollution controls	0.56	This action addresses point source pollutants in the Umatilla and Walla Walla subbasins. It primarily targets chemical pollutants. The planning team (Section 9) identified a high certainty of outcome. Because point sources are easier to control than non-point sources, and means have been identified for assessing load levels in streams of concern, a high effectiveness is assigned here.
	H2O quality mgmt plans	0.32	This action that addresses water quality issues is specified to be applied in the Umatilla and Walla Walla subbasins. It is not specifically stated to be an Agricultural Water Quality Plan (implemented through provisions of Senate Bill 1010) but presumably it could be. See related rationale for effectiveness under "Implement Ag WQP" above. The planning teams that outlined this action (Section 9) identified the degree of implementation for this action to be uncertain in both subbasins but suggested a moderate level of success. The level of effectiveness assumed here is moderate (realized effectiveness will be a function of implementation intensity, which here is also assumed to be moderate).

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Pest mgmt plans for fruit growers	0.32	This action addresses fruit pests in the Walla Walla subbasin. It is assumed here that it encompasses all aspects described below for "Implement IFPnet plans." A moderate level of effectiveness is assumed.
	Municipal stormwater mgmt	0.32	This action addresses municipal stormwater management in the Walla Walla basin. Technology for managing stormwater runoff in municipalities is developed in general and can be applied. The level of effectiveness is related to some degree by how aggressive a program is designed to be. The planning team (Section 9) stated that the outcome of implementation is uncertain. Part of this uncertainty may be related to the human population growth in the targeted areas. A moderate level of effectiveness is assumed here because of the relatively small areal extent of urbanization in the targeted subbasins relative to the extent in other areas of the Pacific Northwest. Effectiveness is likely to be related to the extent of urbanization and remains essentially experimental (Konrad 2003).
	Waterway alteration permitting	0.00	This action would require permitting of waterway alteration activities, presumably that are expected in the mainstem Walla Walla River. “Waterway alteration” means any action that will result in excavation, dredging, filling, rechannelization, construction, or any other type of modification of an aquatic habitat areas occupied by ESA-listed species that will affect the conservation value of that habitat. Under Section 9 of this document, it states "While permit processes implemented by the US Army Corps of Engineers are thorough and actions authorized are protective of aquatic resources, the program lacks personnel resources to insure that terms and conditions of permitted actions are followed. In addition, this agency lacks resources to adequately monitor waterways for non-permitted actions or act upon non-permitted situations reported by other agencies or private parties." This action is meant to provide protection against presumed future waterway alterations in the Walla Walla River. As such, an effectiveness of "no effect" is assigned here that would benefit habitat values.
	Permitting for H2O quality activities	0.00	This action would provide for improved permitting and enforcement of activities that might degrade water quality in the Walla Walla subbasin. The action is only relevant in the present analysis if other actions (such as build-out) are to be analyzed that would degrade water quality, in which case the action would serve protect. As such, an effectiveness of "no effect" is assigned here that would benefit habitat values.
8. Restore upland processes to reduce erosion			
	Convert till farming	0.32	Conversion to no till farming would reduce sediment loading to streams. Replacement of conventional tillage systems for dryland wheat production with new methods, such as direct seed/no till systems, is known to reduce sediment delivery to streams from these typically highly erodible soils. This action would seek to achieve a 95% conversion in targeted areas. A moderate level of effectiveness is assumed though available information is not readily available on effectiveness; realized effectiveness will be strongly driven by the overall scope and distribution of targeted areas.
	Convert to perennial crops	0.32	This action would entail shifting from annual grains to perennial crops in order to reduce erosion. The scope of the action is uncertain but it potentially could produce a significant reduction in sediment delivery to streams. A moderate level of effectiveness was assumed; realized effectiveness will be strongly driven by the overall scope and distribution of targeted areas.
	Implement IFPnet plans	0.32	This action is aimed at promoting use of less toxic pesticides in the concentrated fruit orchards of the Fifteenmile subbasin. The program is described in Cockrum and Omeg (2003). A moderate level of effectiveness is assumed on reported results. Note: action should more correctly be placed under Strategy 7.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Improve/remove forest roads	0.32	Roads are a major source of sediment in managed watersheds. Road closures, obliteration, and improvements known to be effective at reducing sediment loading to streams. A moderate level of effectiveness is assumed; realized effectiveness will be strongly driven by the amount of roads closed or improved (defined by the intensity factor).
	Reforest/fuels management	0.32	This action calls for improvements in fuels management and should overtime reduce potential erosion of soils and sediment delivery to streams. Intensive application should provide a moderate level of effectiveness.
	Upland demo projects	0.32	This action calls for demonstration projects to show the benefits of new concepts in land management, thus their scale of implementation is necessarily small. In areas where implemented, it can be assumed that they should demonstrate benefits, hence a moderate level of effectiveness is assumed.
	BMPS to reduce soil erosion	0.32	Best management practices to promote improved land use practices are generally known and further improvements in understanding can be expected in the near future as there are on-going studies to address this issue. A moderate effectiveness is reasonable to expect as a result of continued progress in how lands are being managed. It is expected that land owners will over time improve their practices in the uplands. (This action is essentially the same as "BMPs on land uses" - the two actions are called for in different subbasins.)
	Remove junipers	0.32	Western juniper has increased in abundance in eastern Oregon due to changes in land use management practices, principally reduction in fire. Juniper removal is one management technique to reduce the density of junipers. Because of the water use of junipers, groundwater levels have been affected (even significantly) where junipers are in high abundance. Removal of junipers has been shown to have a significant effect on water yield where removal is extensive. This can also change vegetation patterns and species, promoting grasses and reducing erosion. It is assumed that effectiveness is moderate when removal occurs on a large enough scale. See for example http://egov.oregon.gov/ODF/AGENCY_AFFAIRS/Juniper_Story.shtml and http://www.oregon.gov/OPSW/stories/lakes_basin.shtml
	Restore native upland plants	0.32	This action would seek to restore natural assemblages of plant species in upland communities, promoting more natural hydrographs and improved erosion control. When intensively conducted, a moderate effectiveness is assumed.
	Invasive plant mgmt & junipers	0.32	This action would combine activities in the two actions above, affording improved erosion control and more natural water yield patterns. When intensively conducted, a moderate effectiveness is assumed.
	BMPs on land uses	0.32	Best management practices to promote improved land use practices are generally known and further improvements in understanding can be expected in the near future as there are on-going studies to address this issue. A moderate effectiveness is reasonable to expect as a result of continued progress in how lands are being managed. It is expected that land owners will over time improve their practices in the uplands.
	CREP & CCRP buffers	0.32	This action would implement a Continuous Conservation Reserve Program and a Conservation Reserve Enhancement Program for streamside buffers, affording voluntary, non-competitive, programs for agricultural landowners built on financial incentives. Voluntary participation by local landowners is sought through a cost share program designed to restore and enhance habitat and increase bank stability along waterways on private lands with a cropping history. It is implemented in areas with highly erodible soils. When implemented fully, it should be quite effective, here it was assumed to have a moderate effectiveness (vs. a higher effectiveness) due to uncertainties in reported results that were reviewed.

Table H-3B. Action effectiveness values.

Strategy	Action	Effect.	Rationale/comment
	Outreach to upland users	0.32	Education and on-going interactions with upland land owners is deemed critical to restore vegetation and reduce erosion. Where intensively implemented, an add-on benefit is assumed, producing a greater effectiveness to targeted practices for reducing erosion. A moderate level of effectiveness is assumed.

Table H-4A and B. Action implementation intensity assumptions and levels applied in analysis (A) and corresponding intensity scalars assigned to each action with rationale/comments (B). See Section 10 for how intensity scalars were applied.

Table H-4A. Action implementation intensity levels.

Intensity level	Definition	Scalar
1	Very high	0.85
2	High	0.40
3	Moderate	0.15
4	Low	0.05
5	Negligible	0.02
6	None	0.00

Table H-4B. Action implementation intensity scalars.

Strategy	Action	Scalar	Rationale/comment
1. Protect/conserve ecological processes			
	Acquisition/conservation	0.05	Areas to be acquired or conserved for habitat values will likely be low relative to the sheer size of areas designated to encompass set-asides.
	Protect rare functioning habitats	0.15	Reasonable attempts would be made to fully protect rare functioning habitats where opportunities exist; assume moderate intensity.
	BMPs to conserve eco processes	0.15	Moderate intensity overall would be reasonable to expect for realizing BMPs in conserving ecological processes.
	Cooperative Agreements	0.40	A high intensity of implementation would be prudent in initiating new cooperative agreements.
	Special mgmt designations	0.05	New Special Management Designations are not expected to exceed a low intensity of implementation.
	Increase wild-scenic status	0.15	New Wild and Scenic Status could likely not be expected to exceed a moderate intensity of implementation.
	Protect access to key habitats	0.00	Issue is covered completely by other actions as this action was described; not given an intensity value here.
	Outreach to users and managers	0.05	Low intensity of implementation is expected for this action because education can be expected to accompany other line item actions.
	Public lands protection	0.05	Protection of public lands are integral part of various other actions within the action list; a low intensity of additional implementation is afforded this action as an add-on to the other actions.
	Waterway setbacks	0.15	Moderate intensity overall would be reasonable to expect for initiating new waterway setbacks in targeted stream segments.
	Enforce floodplain regs	0.15	Moderate intensity overall would be reasonable to expect for implementing new activities designed to enforce floodplain regulations.
	Natural Area Overlay Zone	0.15	Moderate intensity overall would be reasonable to expect for realizing BMPs in conserving ecological processes.
	Legislate priority areas	0.02	A very low (negligible) level of intensity is envisioned in legislating new priority measures. This measure is largely investigative. Many other avenues are considered to be in place or proposed for action to address such issues.
2. Restore fish passage blocked/impaired by barriers			
	Barrier removal	--	All barriers identified in Section 9 to be addressed would be targeted for action.
	Add irrigation screening	0.85	A very high level of intensity of implementation is assumed to add irrigation screening where it is currently lacking.

Table H-4B. Action implementation intensity scalars.

Strategy	Action	Scalar	Rationale/comment
	Pelton Round Butte passage	--	Passage will be implemented at the Pelton Round Butte complex; it is also assumed that passage will be implemented at diversion barriers in Whychus Creek.
	Upgrade irrigation screening	0.40	A high level of implementation intensity overall would be prudent to expect for upgrading screens as they are determined to be under performing.
	Reduce push up dams	0.40	A high level of implementation intensity overall would be prudent to address push up dams in selected stream segments.
	Fish ladder construction	--	This matter is addressed under Barrier removal above.
	Maintain passage facilities	--	It is expected that efforts will be sufficiently implemented to maintain passage facilities in good working condition.
3. Restore floodplain connectivity and function			
	Reconnect floodplain	0.15	A moderate level of implementation intensity overall is reasonable to expect for reconnecting floodplain habitats in selected stream segments.
	Reconnect side channels	0.15	A moderate level of implementation intensity overall is reasonable to expect for reconnecting side channels in selected stream segments.
	Reintroduce beaver	0.15	A moderate level of implementation intensity overall is reasonable to expect for restoring beaver populations as watershed functions are gradually restored, and more normative stream channel and floodplain conditions are restored.
	Restore wet meadows	0.15	A moderate level of implementation intensity overall is reasonable to expect for restoring wet meadows in selected stream segments as related watershed functions are gradually restored.
	Dike removal	0.15	A moderate level of implementation intensity overall is reasonable to expect for dike removal in selected stream segments as watershed function gradually restored.
	Manage beavers	0.05	A low level of implementation intensity is assumed to be needed for beaver management. Uncertainty about issues related to effects of beavers on private properties in the targeted areas exist, however.
4. Restore degraded channel structure/complexity			
	Restore natural channel form	0.15	A moderate level of implementation intensity overall is reasonable to expect for restoring channel form in selected stream segments as related watershed functions are gradually restored.
	Large wood enhancement	0.15	A moderate level of implementation intensity overall is reasonable to expect for actively enhancing large wood quantities in the active channel in selected stream segments (in conjunction with related actions such as LWD education).
	Add structure	0.15	A moderate level of implementation intensity overall is reasonable to expect for adding a diversity of structure to selected stream reach segments.
	Stabilize streambanks	0.15	A moderate level of implementation intensity overall is reasonable to expect for stabilizing streambanks in selected stream segments.
	Build pool weirs	0.02	Because this action frequently is ineffective, only a very low (negligible) level of implementation intensity overall is expected in selected stream segments.
	BMP bridge maintenance	0.02	A low level of implementation is assigned to this action (note: the author of the analysis subsequently concluded that a high level of intensity would be prudent for this action - though this would have an inconsequential effect on the overall analysis due to the very low effectiveness assigned to this action).
	LWD education	0.15	A moderate level of implementation intensity overall is reasonable to expect for providing LWD education in areas targeted for restoration.

Table H-4B. Action implementation intensity scalars.

Strategy	Action	Scalar	Rationale/comment
5. Restore riparian condition and LWD recruitment			
	Restore riparian communities	0.40	A high level of implementation intensity overall should be pursued for this action, as riparian integrity is deemed so important for the overall health of the stream and its populations. Riparian restoration has a very high effectiveness.
	Improve grazing practices	0.15	A moderate level of implementation intensity overall is prudent to expect for improving grazing practices in areas targeted for restoration work.
	Eradicate invasive plants	0.15	A moderate level of implementation intensity overall is reasonable to expect for eradicating invasive plants in areas targeted for restoration work.
	Fencing	0.40	A high level of implementation intensity overall should be pursued for this action in stream segments with opportunities for restoration. Fencing is an effective tool for restoring riparian zones. Riparian restoration has a very high effectiveness.
	Off-stream livestock watering	0.15	A moderate level of implementation intensity overall is prudent to expect for achieving off-stream livestock watering.
	Riparian plantings	0.15	A moderate level of implementation intensity overall is reasonable to expect for using riparian plantings in selected stream segments.
	Increase riparian shading	0.15	A moderate level of implementation intensity overall is reasonable to expect using various means to increase riparian shading in selected stream segments.
	No cultivation buffer zones	0.05	A low level of implementation is assigned to this action due to uncertainties about opportunities for establishing no cultivation buffers.
	Maintain RHCAs on USFS lands	0.85	A high level of implementation intensity overall should be pursued for this action in stream segments targeted with USFW lands.
	Remove riparian roads	0.15	A moderate level of implementation intensity overall is prudent to expect for removal of riparian roads in the stream segments targeted.
	Riparian protection	0.15	A moderate level of implementation intensity overall is prudent to expect protecting riparian areas associated with new riparian measures.
6. Restore natural hydrograph components			
	Ag water conservation	0.15	A moderate level of implementation intensity overall is prudent to expect for initiating new water conservation measures on agricultural lands. This action includes application and not conveyance systems.
	Improve irrigation conveyance	0.40	A high level of implementation intensity overall is warranted for improving irrigation conveyance as an effective way of reducing leakage/loss of water in arid areas selected for restoration work.
	Orchard Ridge/Wolf Run	0.85	A very high level of implementation intensity overall is assumed for completion of these two irrigation systems in Fifteenmile subbasin.
	Urban conservation	0.15	A moderate level of implementation intensity overall is assumed for urban water conservation measures.
	Convert water rights	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities.
	Regulate water withdrawals	0.40	A high level of implementation intensity overall is warranted for monitoring and regulating water withdrawals consistent with laws, regulations, and agreements.
	Water retention structures	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities.
	Increase pool habitat (beaver ponds)	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities that would likely have the desired result for augmenting stream flow.

Table H-4B. Action implementation intensity scalars.

Strategy	Action	Scalar	Rationale/comment
	Floodplain aquifer recharge	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities that would likely have the desired result for augmenting stream flow. The action is seen as being highly experimental.
	H2O rights transfer downstream	0.15	A moderate level of implementation intensity overall is prudent to expect for transfer of water rights downstream, if opportunities avail themselves to implementation.
	Water storage investigate	0.02	This action would be mainly investigative, considering ways of learning new ways of storing water and improving overall efficiency of use in the subbasin. Due to uncertainties, a negligible intensity of implementation is assumed here. Other actions would serve the same purpose and are included with higher intensities.
	No new H2O appropriation	0.00	This action would close areas to new water appropriation. While it would protect against increases in water use, it would have no effect on current use. A zero intensity of implementation would occur that could help restore flow to the stream.
	Criteria for new H2O appropriation	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about real opportunities for new water appropriations.
	Enhance hyporheic flows	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities that would likely have the desired result for augmenting stream flow. The action is seen as being highly experimental.
	Recharge shallow aquifers	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities that would likely have the desired result for augmenting stream flow. The action is seen as being highly experimental.
	Aquifer storage & recovery	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities that would likely have the desired result for augmenting stream flow. The action is seen as being highly experimental.
	Umatilla Basin Project Phase I and II	0.85	A very high level of implementation intensity is assumed in maintaining Phases I and II of the project.
	Umatilla Basin Project Phase III	0.85	A very high level of implementation intensity is assumed in implementing Phase III of the project.
	ISWRs	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about opportunities.
7. Improve degraded water quality			
	Manage irrigation return flow	0.40	A high level of implementation intensity overall is warranted so that irrigators are performing as effectively as they can reasonably do in reducing effects of return flow.
	Measures to improve DO	0.15	A moderate level of implementation intensity overall is prudent to expect for reducing unnatural factors that affect dissolved oxygen in targeted stream segments.
	Reduce chemical pollution	0.05	A low level of implementation intensity is assigned to this action given uncertainties in where and when the problem is occurring.
	Implement Ag WQP	0.40	A high level of implementation intensity overall is expected in the Fifteenmile and Deschutes subbasins in implementing Agricultural Water Quality Plans.
	TMDL monitoring	0.15	A moderate level of implementation intensity is expected for TMDL monitoring in the targeted subbasins.
	Reduce mine discharge toxicants	0.40	A high level of implementation intensity overall is expected to be targeted on known areas of mining pollution in the John Day subbasin.

Table H-4B. Action implementation intensity scalars.

Strategy	Action	Scalar	Rationale/comment
	Animal feeding BMPs	0.15	A moderate level of implementation intensity overall is expected to be targeted on areas used as animal feedlots, as there are only a few sites of concern.
	Point source pollution controls	0.40	A high level of implementation intensity overall should be pursued for this action in targeted stream segments. Point source pollution is readily identifiable and can be addressed through monitoring and attentive solutions.
	H2O quality mgmt plans	0.15	A moderate level of implementation intensity overall is expected in the Umatilla and Walla subbasins in implementing new water quality plans due to uncertainties about participation (as described in Section 9 for this action).
	Pest mgmt plans for fruit growers	0.40	A high level of implementation intensity overall is prudent to expect in targeted stream segments using the IFPnet model developed on in Fifteenmile Creek, based on. The IFP project has grown out of the public's concern over pesticide residues on food, exposure to farm workers, and contamination in the environment (Cockrum and Omeg 2004).
	Municipal stormwater mgmt	0.15	A moderate level of implementation intensity overall is prudent to expect for addressing stormwater runoff in municipal areas given the level of concern that accompanies this in watersheds of the Pacific Northwest as it relates to effects on salmonids (Konrad 2004). Uncertainties exist, however, about effectiveness and approaches are still largely experimental.
	Waterway alteration permitting	--	This action is by intent for protection purposes only -- it provides no restoration purpose. The effectiveness assumption was set to zero, therefore intensity of implementation has no scaling effect in this case.
	Permitting for H2O quality activities	--	This action is by intent for protection purposes only -- it provides no restoration purpose. The effectiveness assumption was set to zero, therefore intensity of implementation has no scaling effect in this case.
8. Restore upland processes to reduce erosion			
	Convert till farming	0.15	A moderate level of implementation intensity overall is prudent to expect for reducing erosion through this action given levels of concern about soil loss and sedimentation of streams in the targeted subbasins.
	Convert to perennial crops	0.15	A moderate level of implementation intensity overall is prudent to expect for reducing erosion through this action given levels of concern about soil loss and sedimentation of streams in the targeted subbasins.
	Implement IFPnet plans	0.40	A high level of implementation intensity overall is prudent to expect in targeted stream segments using the IFPnet model developed on in Fifteenmile Creek, based on. The IFP project has grown out of the public's concern over pesticide residues on food, exposure to farm workers, and contamination in the environment (Cockrum and Omeg 2004).
	Improve/remove forest roads	0.40	A high level of implementation intensity overall is expected for this action in targeted areas of the subbasins. Forest roads are frequently major sources of sediment in streams of the Pacific Northwest, including those in central and northeast Oregon.
	Reforest/fuels management	0.40	A high level of implementation intensity overall is expected for this action in targeted areas of the subbasins. Significant concerns about forest health and fire management exist in the forested portions of watersheds in central and northeast Oregon.
	Upland demo projects	0.02	An overall very low (negligible) implementation intensity is expected for this action given uncertainties about benefits relative to other actions with known benefits.

Table H-4B. Action implementation intensity scalars.

Strategy	Action	Scalar	Rationale/comment
	BMPS to reduce soil erosion	0.40	A high level of implementation intensity is prudent to achieve BMPs on land practices that result in elevated sediment delivery to targeted segments of streams in the designated subbasins (Fifteenmile and Deschutes). The planning teams that described actions in Section 9 identified certainty of outcome for this action as high, indicating a high degree of participation by stakeholders.
	Remove junipers	0.15	A moderate level of implementation intensity is expected to reduce juniper abundance in targeted areas in the Deschutes subbasin. Benefits accrue to water conservation, fire management, and juniper harvesters. See planninhttp://egov.oregon.gov/ODF/AGENCY_AFFAIRS/Juniper_Story.shtml
	Restore native upland plants	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about participation suggested in description of action in Section 9 in the designated subbasins.
	Invasive plant mgmt & junipers	0.05	A low level of implementation intensity is assigned to this action due to uncertainties about participation suggested in description of action in Section 9 in the designated subbasins.
	BMPs on land uses	0.15	A moderate level of implementation intensity is expected to achieve BMPs on land practices associated with a variety of factors afffecting targeted segments of streams in the designated subbasins (John Day, Umatilla, and Walla Walla). The planning teams that described actions in Section 9 identified certainty of outcome for this action as moderate based on uncertainties about extent of voluntary participation by stakeholders.
	CREP & CCRP buffers	0.15	A moderate level of implementation intensity is expected for participation in the CREP and CCRP programs in the Walla Walla subbasin. Walla Walla County has roughly 25% of the CREP for the entire state of Washington, though state funding is currently uncertain.
	Outreach to upland users	0.02	Very low (negligible) intensity of implementation is projected for this action because education can be expected to accompany other line item actions.

Table H-5. Action effectiveness lag scalars applied to habitat actions. Lag scalars are assumed values, representing the expected amount of the potential effectiveness that would be realized 25 years after implementation. A lag scalar value reflects the expected rate that an action's effectiveness will mature with time (e.g., due to tree growth, change in sediment load, reshaping of hydrograph) . All lag scalars were assumed to attain values of 1.0 after 100 years. See Section 10 for how lag scalars were applied.

Table H-5. Action effectiveness lag scalars at 25 years.

Strategy	Action	Scalar
1. Protect/conserve ecological processes		
	Acquisition/conservation	0.50
	Protect rare functioning habitats	0.80
	BMPs to conserve eco processes	0.80
	Cooperative Agreements	0.70
	Special mgmt designations	0.70
	Increase wild-scenic status	0.70
	Protect access to key habitats	0.70
	Outreach to users and managers	0.70
	Public lands protection	0.50
	Waterway setbacks	0.80
	Enforce floodplain regs	0.80
	Natural Area Overlay Zone	1.00
	Legislate priority areas	0.80
2. Restore fish passage blocked/impaired by barriers		
	Barrier removal	1.00
	Add irrigation screening	1.00
	Pelton Round Butte passage	1.00
	Upgrade irrigation screening	1.00
	Reduce push up dams	1.00
	Fish ladder construction	1.00
	Maintain passage facilities	1.00
3. Restore floodplain connectivity and function		
	Reconnect floodplain	0.80
	Reconnect side channels	0.80
	Reintroduce beaver	0.80
	Restore wet meadows	0.70
	Dike removal	0.90
	Manage beavers	0.90
4. Restore degraded channel structure/complexity		
	Restore natural channel form	0.80
	Large wood enhancement	1.00
	Add structure	0.90
	Stabilize streambanks	0.90
	Build pool weirs	1.00
	BMP bridge maintenance	1.00
	LWD education	1.00

Table H-5. Action effectiveness lag scalars at 25 years.

Strategy	Action	Scalar
5. Restore riparian condition and LWD recruitment		
	Restore riparian communities	0.70
	Improve grazing practices	0.80
	Eradicate invasive plants	0.90
	Fencing	0.80
	Off-stream livestock watering	1.00
	Riparian plantings	0.80
	Increase riparian shading	0.80
	No cultivation buffer zones	1.00
	Maintain RHCAs on USFS lands	0.70
	Remove riparian roads	0.90
	Riparian protection	1.00
6. Restore natural hydrograph components		
	Ag water conservation	1.00
	Improve irrigation conveyance	1.00
	Orchard Ridge/Wolf Run	1.00
	Urban conservation	1.00
	Convert water rights	1.00
	Regulate water withdrawals	1.00
	Water retention structures	1.00
	Increase pool habitat (beaver ponds)	0.80
	Floodplain aquifer recharge	0.70
	H2O rights transfer downstream	0.70
	Water storage investigate	1.00
	No new H2O appropriation	1.00
	Criteria for new H2O appropriation	0.80
	Enhance hyporheic flows	0.80
	Recharge shallow aquifers	0.50
	Aquifer storage & recovery	0.70
	Umatilla Basin Project Phase I and II	1.00
	Umatilla Basin Project Phase III	1.00
	ISWRs	1.00
7. Improve degraded water quality		
	Manage irrigation return flow	1.00
	Measures to improve DO	1.00
	Reduce chemical pollution	0.80
	Implement Ag WQP	1.00
	TMDL monitoring	1.00
	Reduce mine discharge toxicants	0.70
	Animal feeding BMPs	1.00
	Point source pollution controls	0.80
	H2O quality mgmt plans	0.80

Table H-5. Action effectiveness lag scalars at 25 years.

Strategy	Action	Scalar
	Pest mgmt plans for fruit growers	0.70
	Municipal stormwater mgmt	0.70
	Waterway alteration permitting	0.70
	Permitting for H2O quality activities	0.70
8. Restore upland processes to reduce erosion		
	Convert till farming	0.80
	Convert to perennial crops	0.80
	Implement IFPnet plans	0.80
	Improve/remove forest roads	0.70
	Reforest/fuels management	0.50
	Upland demo projects	0.80
	BMPS to reduce soil erosion	0.70
	Remove junipers	0.80
	Restore native upland plants	0.70
	Invasive plant mgmt & junipers	0.70
	BMPs on land uses	0.80
	CREP & CCRP buffers	0.70
	Outreach to upland users	0.80

Table H-6. Action implementation schedule scalars at 25 years applied to habitat actions. Implementation schedule scalars define how the schedule for implementing an action—relative to what might be considered year 0 of a recovery program—would affect realized effectiveness in either year 25 or year 100 of the program. Use of this scalar in the analysis recognizes that the recovery programs will be long-term in implementation due to their very extensive scope. The planning teams who described actions (Section 9) specified implementation schedules. See Section 10 for how lag scalars were applied.

Table H-6. Action implementation schedule scalars at 25 years.

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
1. Protect/conserve ecological processes						
	Acquisition/conservation	0.80	0.96	0.80	0.80	0.80
	Protect rare functioning habitats	0.96	0.96	0.60		0.60
	BMPs to conserve eco processes	0.60	0.60	0.60	0.60	0.60
	Cooperative Agreements		0.80	0.80		
	Special mgmt designations		0.96	0.96		
	Increase wild-scenic status			0.96		
	Protect access to key habitats			0.80		
	Outreach to users and managers			0.60		
	Public lands protection				0.60	0.60
	Waterway setbacks				0.60	0.60
	Enforce floodplain regs				0.60	0.60
	Natural Area Overlay Zone				0.96	0.96
	Legislate priority areas				0.60	0.60
2. Restore fish passage blocked/impaired by barriers						
	Barrier removal	0.60	0.80	0.60	0.96	0.80
	Add irrigation screening	0.80	0.60	0.60	0.60	0.60
	Pelton Round Butte passage		0.80			
	Upgrade irrigation screening		0.60	0.80	0.60	0.60
	Reduce push up dams			0.60		
	Fish ladder construction			0.60	0.80	0.80
	Maintain passage facilities				0.96	0.96
3. Restore floodplain connectivity and function						
	Reconnect floodplain	0.80	0.60	0.60	0.80	0.80
	Reconnect side channels	0.80	0.60	0.60	0.80	0.80
	Reintroduce beaver	0.80	0.60	0.60		
	Restore wet meadows			0.80		
	Dike removal				0.80	0.80
	Manage beavers					0.60
4. Restore degraded channel structure/complexity						
	Restore natural channel form	0.60	0.60	0.60	0.60	0.60
	Large wood enhancement	0.80	0.60	0.80	0.96	0.96
	Add structure	0.80	0.60			
	Stabilize streambanks	0.80	0.60	0.60	0.80	0.80
	Build pool weirs				0.60	0.60
	BMP bridge maintenance					0.60
	LWD education					0.60
5. Restore riparian condition and LWD recruitment						
	Restore riparian communities	0.60	0.60	0.60	0.60	0.60
	Improve grazing practices	0.60	0.60	0.60	0.60	0.60
	Eradicate invasive plants	0.60	0.60			
	Fencing	0.60	0.96		0.60	0.60

Table H-6. Action implementation schedule scalars at 25 years.

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
	Off-stream livestock watering	0.60	0.60			
	Riparian plantings	0.60				
	Increase riparian shading		0.60	0.60		
	No cultivation buffer zones				0.60	0.60
	Maintain RHCAs on USFS lands				0.60	
	Remove riparian roads				0.60	0.60
	Riparian protection					0.60
6. Restore natural hydrograph components						
	Ag water conservation	0.60	0.80	0.60	0.96	
	Improve irrigation conveyance	0.80	0.96	0.60		0.60
	Orchard Ridge/Wolf Run	0.80				
	Urban conservation	0.80				
	Convert water rights	0.60	0.96	0.60	0.60	0.80
	Regulate water withdrawals	0.60	0.60	0.60	0.60	0.80
	Water retention structures		0.96			
	Increase pool habitat (beaver ponds)			0.60		
	Floodplain aquifer recharge			0.60		
	H2O rights transfer downstream				0.60	0.80
	Water storage investigate					0.60
	No new H2O appropriation					0.60
	Criteria for new H2O appropriation					0.60
	Enhance hyporheic flows					0.96
	Recharge shallow aquifers					0.60
	Aquifer storage & recovery					0.60
	Umatilla Basin Project Phase I and II				0.60	
	Umatilla Basin Project Phase III				0.60	
	ISWRs				0.60	0.60
7. Improve degraded water quality						
	Manage irrigation return flow	0.80	0.60	0.80		
	Measures to improve DO	0.80	0.80			
	Reduce chemical pollution	0.80	0.80	0.80		
	Implement Ag WQP	0.80	0.96			
	TMDL monitoring		0.80	0.80		
	Reduce mine discharge toxicants			0.60		
	Animal feeding BMPs			0.96		
	Point source pollution controls				0.80	0.80
	H2O quality mgmt plans				0.80	0.80
	Pest mgmt plans for fruit growers					0.60
	Municipal stormwater management					0.60
	Waterway alteration permitting					0.80
	Permitting for H2O quality activities					0.80
8. Restore upland processes to reduce erosion						
	Convert till farming	0.96	0.96	0.60		
	Convert to perennial crops	0.60	0.96			
	Implement IFPnet plans	0.80				
	Improve/remove forest roads	0.60	0.60	0.60	0.60	0.60
	Reforest/fuels management	0.60	0.60			
	Upland demo projects	0.80		0.60	0.60	0.60
	BMPS to reduce soil erosion	0.80	0.80			

Table H-6. Action implementation schedule scalars at 25 years.

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
	Remove junipers		0.96			
	Restore native upland plants		0.60	0.60	0.60	0.60
	Invasive plant mgmt & junipers			0.60		
	BMPs on land uses			0.60	0.60	0.60
	CREP & CCRP buffers					0.80
	Outreach to upland users					0.60

Table H-7. Action implementation schedule scalars at 100 years applied to habitat actions. Implementation schedule scalars define how the schedule for implementing an action—relative to what might be considered year 0 of a recovery program—would affect realized effectiveness in either year 25 or year 100 of the program. Use of this scalar in the analysis recognizes that the recovery programs will be long-term in implementation due to their very extensive scope. The planning teams who described actions (Section 9) specified implementation schedules. See Section 10 for how lag scalars were applied.

Table H-7. Action implementation schedule scalars at 100 years.

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
1. Protect/conserve ecological processes						
	Acquisition/conservation	0.95	0.99	0.95	0.95	0.95
	Protect rare functioning habitats	0.99	0.99	0.90		0.90
	BMPs to conserve eco processes	0.90	0.90	0.90	0.90	0.90
	Cooperative Agreements		0.95	0.95		
	Special mgmt designations		0.99	0.99		
	Increase wild-scenic status			0.99		
	Protect access to key habitats			0.95		
	Outreach to users and managers			0.90		
	Public lands protection				0.90	0.90
	Waterway setbacks				0.90	0.90
	Enforce floodplain regs				0.90	0.90
	Natural Area Overlay Zone				0.99	0.99
	Legislate priority areas				0.90	0.90
2. Restore fish passage blocked/impaired by barriers						
	Barrier removal	0.90	0.95	0.90	0.99	0.95
	Add irrigation screening	0.95	0.90	0.90	0.90	0.90
	Pelton Round Butte passage		0.95			
	Upgrade irrigation screening		0.90	0.95	0.90	0.90
	Reduce push up dams			0.90		
	Fish ladder construction			0.90	0.95	0.95
	Maintain passage facilities				0.99	0.99
3. Restore floodplain connectivity and function						
	Reconnect floodplain	0.95	0.90	0.90	0.95	0.95
	Reconnect side channels	0.95	0.90	0.90	0.95	0.95
	Reintroduce beaver	0.95	0.90	0.90		
	Restore wet meadows			0.95		
	Dike removal				0.95	0.95
	Manage beavers					0.90
4. Restore degraded channel structure/complexity						
	Restore natural channel form	0.90	0.90	0.90	0.90	0.90
	Large wood enhancement	0.95	0.90	0.95	0.99	0.99
	Add structure	0.95	0.90			
	Stabilize streambanks	0.95	0.90	0.90	0.95	0.95
	Build pool weirs				0.90	0.90
	BMP bridge maintenance					0.90
	LWD education					0.90

Table H-7. Action implementation schedule scalars at 100 years.

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
5. Restore riparian condition and LWD recruitment						
	Restore riparian communities	0.90	0.90	0.90	0.90	0.90
	Improve grazing practices	0.90	0.90	0.90	0.90	0.90
	Eradicate invasive plants	0.90	0.90			
	Fencing	0.90	0.99		0.90	0.90
	Off-stream livestock watering	0.90	0.90			
	Riparian plantings	0.90				
	Increase riparian shading		0.90	0.90		
	No cultivation buffer zones				0.90	0.90
	Maintain RHCAs on USFS lands				0.90	
	Remove riparian roads				0.90	0.90
	Riparian protection					0.90
6. Restore natural hydrograph components						
	Ag water conservation	0.90	0.95	0.90	0.99	
	Improve irrigation conveyance	0.95	0.99	0.90		0.90
	Orchard Ridge/Wolf Run	0.95				
	Urban conservation	0.95				
	Convert water rights	0.90	0.99	0.90	0.90	0.95
	Regulate water withdrawals	0.90	0.90	0.90	0.90	0.95
	Water retention structures		0.99			
	Increase pool habitat (beaver ponds)			0.90		
	Floodplain aquifer recharge			0.90		
	H2O rights transfer downstream				0.90	0.95
	Water storage investigate					0.90
	No new H2O appropriation					0.90
	Criteria for new H2O appropriation					0.90
	Enhance hyporheic flows					0.99
	Recharge shallow aquifers					0.90
	Aquifer storage & recovery					0.90
	Umatilla Basin Project Phase I and II				0.90	
	Umatilla Basin Project Phase III				0.90	
	ISWRs				0.90	0.90
7. Improve degraded water quality						
	Manage irrigation return flow	0.95	0.90	0.95		
	Measures to improve DO	0.95	0.95			
	Reduce chemical pollution	0.95	0.95	0.95		
	Implement Ag WQP	0.95	0.99			
	TMDL monitoring		0.95	0.95		
	Reduce mine discharge toxicants			0.90		
	Animal feeding BMPs			0.99		
	Point source pollution controls				0.95	0.95
	H2O quality mgmt plans				0.95	0.95
	Pest mgmt plans for fruit growers					0.90

Table H-7. Action implementation schedule scalars at 100 years.

Strategy	Action	Fifteenmile	Deschutes	John Day	Umatilla	Walla Walla
	Municipal stormwater management					0.90
	Waterway alteration permitting					0.95
	Permitting for H2O quality activities					0.95
8. Restore upland processes to reduce erosion						
	Convert till farming	0.99	0.99	0.90		
	Convert to perennial crops	0.90	0.99			
	Implement IFPnet plans	0.95				
	Improve/remove forest roads	0.90	0.90	0.90	0.90	0.90
	Reforest/fuels management	0.90	0.90			
	Upland demo projects	0.95		0.90	0.90	0.90
	BMPS to reduce soil erosion	0.95	0.95			
	Remove junipers		0.99			
	Restore native upland plants		0.90	0.90	0.90	0.90
	Invasive plant mgmt & junipers			0.90		
	BMPs on land uses			0.90	0.90	0.90
	CREP & CCRP buffers					0.95
	Outreach to upland users					0.90

Table H-8. Attribute scalars applied to habitat actions. Attribute scalars define whether the potential effectiveness of an action will be the full amount (scalar = 1) or reduced due to an attribute effect. Some actions have no effect on some attributes (scalar = 0). For each action, attributes were identified as being affected or not affected. A scalar of 1 was assigned to any attribute that would be affected, except for those that characterize some aspect of sediment, flow, and temperature. Scalars for these were set to 0.75, recognizing that these attributes are broadly affected by watershed conditions and can be more difficult to influence than attributes driven mainly by site-specific conditions. See Section 10 for how scalars were applied. See Table H-9 for definitions of attributes.

Table H-8. Attribute scalars.

Strategy	Action	BdScour	BenComRch	ConfineHydro	DisOxy	Emb	FlwDielVar	FlwHigh	FlwIntraAnn	FlwLow	FnSedi	HbOfChFctr	HbPls	Icing	MscToxWat	NutEnrch	Obstr	RipFunc	TmpMonMn	TmpMonMx	TmpSptVar	Turb	WdDeb	Wdrwl	WidthMn	WidthMx
1. Protect/conserve ecological processes																										
	Acquisition/conservation	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Protect rare functioning habitats	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	BMPs to conserve eco processes	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Cooperative Agreements	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Special mgmt designations	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Increase wild-scenic status	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Protect access to key habitats						1.00	0.75	0.75	0.75		1.00						1.00								
	Outreach to users and managers	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00
	Public lands protection	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Waterway setbacks	1.00	1.00	1.00	1.00	0.75			0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Enforce floodplain regs	1.00	1.00	1.00	1.00	0.75			0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Natural Area Overlay Zone	1.00	1.00	1.00	1.00	0.75	0.75		0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Legislate priority areas	1.00	1.00	1.00	1.00	0.75	0.75		0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
2. Restore fish passage blocked/impaired by barriers							0.75																			
	Barrier removal						0.75										1.00									
	Add irrigation screening																							1.00		
	Pelton Round Butte passage																1.00									
	Upgrade irrigation screening																							1.00		
	Reduce push up dams	1.00								0.75														1.00		
	Fish ladder construction																1.00									
	Maintain passage facilities																1.00									
3. Restore floodplain connectivity and function																										
	Reconnect floodplain	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Reconnect side channels	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Reintroduce beaver	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Restore wet meadows	1.00	1.00				1.00	0.75	0.75	0.75		1.00		1.00				1.00	0.75	0.75	0.75					

Table H-8. Attribute scalars.

Strategy	Action	BdScour	BenComRch	ConfineHydro	DisOxy	Emb	FlwDielVar	FlwHigh	FlwIntraAnn	FlwLow	FnSedi	HbOfChFctr	HbPls	Icing	MscToxWat	NutEnrch	Obstr	RipFunc	TmpMonMn	TmpMonMx	TmpSptVar	Turb	WdDeb	Wdrwl	WidthMn	WidthMx
	Dike removal	1.00	1.00	1.00	1.00	0.75		0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Manage beavers	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
4. Restore degraded channel structure/complexity																										
	Restore natural channel form	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Large wood enhancement	1.00		1.00						0.75		1.00	1.00								0.75		1.00		1.00	1.00
	Add structure	1.00		1.00						0.75		1.00	1.00								0.75		1.00		1.00	1.00
	Stabilize streambanks	1.00	1.00	1.00	1.00	0.75				0.75	0.75	1.00	1.00	1.00				1.00			0.75	1.00	1.00		1.00	1.00
	Build pool weirs									0.75			1.00													
	BMP bridge maintenance	1.00											1.00													
	LWD education	1.00		1.00						0.75		1.00	1.00								0.75		1.00		1.00	1.00
5. Restore riparian condition and LWD recruitment																										
	Restore riparian communities	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Improve grazing practices	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Eradicate invasive plants									0.75		1.00	1.00					1.00								
	Fencing	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Off-stream livestock watering	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Riparian plantings													1.00				1.00	0.75	0.75	0.75					
	Increase riparian shading													1.00				1.00	0.75	0.75	0.75					
	No cultivation buffer zones	1.00	1.00	1.00	1.00	0.75					0.75							1.00	0.75	0.75	0.75	1.00				
	Maintain RHCAs on USFS lands	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Remove riparian roads	1.00	1.00	1.00	1.00	0.75					0.75							1.00	0.75	0.75	0.75	1.00				
	Riparian protection	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
6. Restore natural hydrograph components																										
	Ag water conservation				1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00						0.75	0.75	0.75	1.00			1.00	1.00
	Improve irrigation conveyance				1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00						0.75	0.75	0.75	1.00			1.00	1.00
	Orchard Ridge/Wolf Run	1.00			1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00			1.00	1.00
	Urban conservation	1.00			1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00			1.00	1.00
	Convert water rights	1.00			1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00			1.00	1.00
	Regulate water withdrawals	1.00			1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00			1.00	1.00
	Water retention structures	1.00			1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00			1.00	1.00
	Increase pool habitat (beaver ponds)	1.00								0.75		1.00	1.00		1.00											
	Floodplain aquifer recharge	1.00								0.75		1.00		1.00	1.00				0.75	0.75	0.75					
	H2O rights transfer downstream				1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00						0.75	0.75	0.75	1.00			1.00	1.00
	Water storage investigate	1.00	1.00		1.00			0.75	0.75	0.75	0.75		1.00						0.75	0.75	0.75				1.00	
	No new H2O appropriation	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00		1.00	1.00	1.00

Table H-8. Attribute scalars.

Strategy	Action	BdScour	BenComRch	ConfineHydro	DisOxy	Emb	FlwDielVar	FlwHigh	FlwIntraAnn	FlwLow	FnSedi	HbOfChFctr	HbPls	Icing	MscToxWat	NutEnrich	Obstr	RipFunc	TmpMonMn	TmpMonMx	TmpSptVar	Turb	WdDeb	Wdrwl	WidthMn	WidthMx
	Criteria for new H2O appropriation	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00	1.00						0.75	0.75	1.00			1.00	1.00
	Enhance hyporheic flows	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00	1.00					0.75	0.75	0.75	1.00			1.00	1.00
	Recharge shallow aquifers	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00	1.00	1.00			0.75	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Aquifer storage & recovery	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00	1.00	1.00				0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Umatilla Basin Project Phase I and II		1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00	1.00			1.00
	Umatilla Basin Project Phase III				1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00	1.00			1.00
	ISWRs	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00	1.00	1.00				0.75	0.75	0.75	1.00		1.00	1.00	1.00
7. Improve degraded water quality		1.00													1.00									1.00		
	Manage irrigation return flow		1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00		1.00				0.75	0.75	0.75	1.00			1.00	1.00
	Measures to improve DO				1.00					0.75					1.00	1.00		1.00	0.75	0.75	0.75	1.00				
	Reduce chemical pollution				1.00	0.75									1.00	1.00						1.00				
	Implement Ag WQP				1.00					0.75					1.00	1.00		1.00	0.75	0.75	0.75	1.00				
	TMDL monitoring																									
	Reduce mine discharge toxicants														1.00											
	Animal feeding BMPs		1.00		1.00	1.00					1.00					1.00						1.00				
	Point source pollution controls				1.00	0.75									1.00	1.00						1.00				
	H2O quality mgmt plans				1.00	0.75									1.00	1.00			0.75	0.75	0.75	1.00				
	Pest mgmt plans for fruit growers														1.00											
	Municipal stormwater mgmt	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75		1.00						0.75	0.75	0.75	1.00			1.00	1.00
	Waterway alteration permitting	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Permitting for H2O quality activities				1.00	0.75									1.00	1.00			0.75	0.75	0.75	1.00				
8. Restore upland processes to reduce erosion																										
	Convert till farming	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00		1.00	1.00						1.00			1.00	1.00
	Convert to perennial crops	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00		1.00	1.00						1.00			1.00	1.00
	Implement IFPnet plans				1.00	0.75									1.00	1.00						1.00				
	Improve/remove forest roads	1.00		1.00		0.75	1.00	0.75	0.75	0.75	0.75		1.00					1.00	0.75	0.75	0.75	1.00			1.00	1.00
	Reforest/fuels management	1.00		1.00		0.75	1.00	0.75	0.75	0.75	0.75		1.00					1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00
	Upland demo projects	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	1.00							1.00	0.75	0.75	0.75	1.00			1.00	1.00
	BMPS to reduce soil erosion	1.00		1.00		0.75	1.00	0.75	0.75	0.75	0.75		1.00					1.00	0.75	0.75	0.75	1.00			1.00	1.00
	Remove junipers	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75								1.00	0.75	0.75	0.75	1.00			1.00	1.00
	Restore native upland plants	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75								1.00	0.75	0.75	0.75	1.00			1.00	1.00
	Invasive plant mgmt & junipers	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75								1.00	0.75	0.75	0.75	1.00			1.00	1.00
	BMPs on land uses	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	1.00							1.00	0.75	0.75	0.75	1.00			1.00	1.00
	CREP & CCRP buffers	1.00	1.00	1.00	1.00	0.75	1.00	0.75	0.75	0.75	0.75	1.00	1.00	1.00	1.00	1.00		1.00	0.75	0.75	0.75	1.00	1.00		1.00	1.00

Table H-8. Attribute scalars.

Strategy	Action	BdScour	BenComRch	ConfineHydro	DisOxy	Emb	FlwDielVar	FlwHigh	FlwIntraAnn	FlwLow	FnSedi	HbOfChFctr	HbPls	Icing	MscToxWat	NutEnrch	Obstr	RipFunc	TmpMonMn	TmpMonMx	TmpSptVar	Turb	WdDeb	Wdrwl	WidthMn	WidthMx
	Outreach to upland users	1.00	1.00		1.00	0.75	1.00	0.75	0.75	0.75	1.00							1.00	0.75	0.75	0.75	1.00			1.00	1.00

Table H-9. Definitions of freshwater habitat attributes shown in Table H-8 (shown as attribute codes there). The attributes are applied in EDT analysis.

Attribute code	Attribute name	Definition
BdScour	Bed scour	Average depth and frequency of bed scour of small-cobble/gravel substrates of pool-tail outs, glides, and riffles during high flow events.
BenComRch	Benthos diversity and production	Measure of the diversity and production of the benthos community.
ConfineHydro	Confinement - Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized.
DisOxy	Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.
Emb	Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment.
FlwDielVar	Flow - Intra daily (diel) variation	Variability in flow level during a daily period. This attribute is informative mainly for regulated rivers or when flow patterns are influenced by storm water runoff.
FlwHigh	Flow - change in interannual variability in high flows	A measure of between year variation in magnitude of high flow levels and/or the extent of change in overall high flow level during a month relative to an undisturbed watershed of comparable size, geology, and geography.
FlwIntraAnn	Flow - intra-annual flow pattern	The average extent of intra-annual flow variation during a month -- a measure of a stream's "flashiness" during a season.
FlwLow	Flow - changes in interannual variability in low flows	A measure of between year variation in the severity of low flow discharge during a month. Variation in low flows as applied here is relative to an undisturbed watershed of comparable size, geology, and geography.
FnSedi	Fine sediment	Percentage of fine sediment within pool-tailouts and riffles.
HbOfChFctr	Habitat type - off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.
HbPls	Habitat type - primary pools	Percentage of the wetted channel surface area comprising pools.
Icing	Icing	Extent (magnitude and frequency) of icing events.
MscToxWat	Miscellaneous toxic pollutants - water column	The extent of miscellaneous toxic pollantants within the water column.
NutEnrch	Nutrient enrichment	The amount of nutrient enrichment consisting of such items as ammonia, nitrogen, phosphorous.
Obstr	Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hinderances to migration caused by pollutants or lack of oxygen).
RipFunc	Riparian function	A measure of riparian function that has been altered within the reach.

Attribute code	Attribute name	Definition
TmpMonMn	Temperature - daily minimum (by month)	Minimum water temperatures within the stream reach reach during a month.
TmpMonMx	Temperature - daily maximum (by month)	Maximum water temperatures within the stream reach reach during a month.
TmpSptVar	Temperature - spatial variation	The extent of water temperature variation within the reach as influenced by inputs of groundwater.
Turb	Turbidity	The relative extent of turbidity episodes within the stream reach.
WdDeb	Wood	The amount of wood within the reach. Note definition of "large wood" under terms/clarification.
Wdrwl	Water withdrawals	The number and relative size of water withdrawals in the stream reach.
WidthMn	Channel month Minimum width (ft)	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.
WidthMx	Channel month Maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels.

Out-of-Basin Survival Rates Assumptions

Out-of-subbasin survival rates incorporated into the AHA modeling are listed in Tables H-10 to H-14; their derivation is described below. Each table lists survivals by life stage segment for baseline, current, and prospective future conditions. Prospective future conditions are the scenarios formulated in a stepwise fashion by adding in actions sequentially, each effect being added to the previous scenario (see Table 10-1). Survivals are listed for three life stage segments, followed by the combined survival across the three segments. The survival for each of the three life stage segments encompasses the following:

1. Smolt to smolt (smt-smt) – survival of migrant smolts from the time of departing the subbasin (i.e., entry into the mainstem Columbia River) to the point of immediately downstream of Bonneville Dam;
2. Estuary and ocean (est-ocn) – the smolt to adult survival rate (SAR) covering the entirety of the time spent in the Columbia River estuary (i.e., beginning immediately below Bonneville Dam) and ocean as smolts, sub-adults, and adults; and
3. Adult to adult (adt-adt) – survival of returning adults from the time of departing the Columbia River estuary (i.e., beginning with passage at Bonneville Dam) to the point of entry into the natal subbasin.

Baseline survival rates were formulated from several sources. The baseline smolt to smolt rates were provided for each population by NOAA Fisheries (correspondence between Ritchie Graves and Tracy Hillman dated August 9, 2007). The combined estuary and ocean survival rate was based on an average default value applied in EDT analysis, here rounded to an average of 7.5%. This average rate was applied to each of the populations modeled in AHA. The adult to adult rate

was derived by using the survival rate applied in EDT (extracted by analyzing life history trajectories used in EDT modeling) and the average mainstem harvest rate for the baseline period (converted to a survival rate).[1]

The current years survival rates for each life stage segment k ($Csurv_k$) then are derived as

$$Csurv_k = Bsurv_k \times \prod m_{i,j}$$

where $Bsurv_k$ is baseline survival rate in life stage segment k

$m_{i,j}$ is the survival multiplier for survival factor i and scenario j (here the scenario is the current condition)

The prospective future years (i.e., including future scenario actions) survival rates for each life stage segment k ($Psurv_k$) are then derived as

$$Psurv_k = Csurv_k \times \prod m_{i,j}$$

[1] / The average harvest rate (0.1267) for years 1991-2003 was used for the baseline period, as given in Appendix G of the Comprehensive Analysis dated August 2007.

Table H-10. Out-of-subbasin survival rates applied in AHA modeling for baseline (B), current (C), and prospective future action scenarios for Fifteenmile Creek winter steelhead. Future action scenarios were modeled sequentially, where hydro (Hyd) actions were added to current conditions, predation (Pred) actions were added to hydro, estuarine (Est) actions were added to predation, and harvest (Harv) actions were added to estuarine. Decreased (MarLow) and increased (MarHigh) marine survival rate scenarios were then added to the combined prospective future action scenarios.

Life stage	Scen	Survival multiplier by factor						Scen surv
		Hydro	Avian	Pikemin	Estuary	Harvest	Marine	
Smt-smt	B							0.9140
Est-ocn	B							0.0750
Adt-adt	B							0.8466
Smt-adt	B							**0.0580**
Smt-smt	C	1.031	0.997	1.000				0.9395
Est-ocn	C				1.003		1.000	0.0752
Adt-adt	C					1.043		0.8830
Smt-adt	C							**0.0624**
Smt-smt	Hyd	1.002	1.000	1.000				0.9414
Est-ocn	Hyd				1.000		1.000	0.0752
Adt-adt	Hyd					1.000		0.8830
Smt-adt	Hyd							**0.0625**
Smt-smt	Pred	1.002	1.034	1.010				0.9831
Est-ocn	Pred				1.000		1.000	0.0752
Adt-adt	Pred					1.000		0.8830
Smt-adt	Pred							**0.0653**
Smt-smt	Est	1.002	1.034	1.010				0.9831
Est-ocn	Est				1.057		1.000	0.0795
Adt-adt	Est					1.000		0.8830
Smt-adt	Est							**0.0690**
Smt-smt	Harv	1.002	1.034	1.010				0.9831
Est-ocn	Harv				1.057		1.000	0.0795
Adt-adt	Harv					1.000		0.8830
Smt-adt	Harv							**0.0690**
Smt-smt	MarLow	1.002	1.034	1.010				0.9831
Est-ocn	MarLow				1.057		0.750	0.0596
Adt-adt	MarLow					1.000		0.8830
Smt-adt	MarLow							**0.0518**
Smt-smt	MarHigh	1.002	1.034	1.010				0.9831
Est-ocn	MarHigh				1.057		1.250	0.0994
Adt-adt	MarHigh					1.000		0.8830
Smt-adt	MarHigh							**0.0863**

Table H-11. Out-of-subbasin survival rates applied in AHA modeling for baseline (B), current (C), and prospective future action scenarios for Deschutes River Eastside and Westside summer steelhead. Future action scenarios were modeled sequentially, where hydro (Hyd) actions were added to current conditions, predation (Pred) actions were added to hydro, estuarine (Est) actions were added to predation, and harvest (Harv) actions were added to estuarine. Decreased (MarLow) and increased (MarHigh) marine survival rate scenarios were then added to the combined prospective future action scenarios.

Life stage	Scen	Survival multiplier by factor						Scen surv
		Hydro	Avian	Pikemin	Estuary	Harvest	Marine	
Smt-smt	B							0.7580
Est-ocn	B							0.0750
Adt-adt	B							0.8015
Smt-adt	B							**0.0456**
Smt-smt	C	1.064	0.997	1.000				0.8041
Est-ocn	C				1.003		1.000	0.0752
Adt-adt	C					1.043		0.8360
Smt-adt	C							**0.0506**
Smt-smt	Hyd	1.051	1.000	1.000				0.8451
Est-ocn	Hyd				1.000		1.000	0.0752
Adt-adt	Hyd					1.000		0.8360
Smt-adt	Hyd							**0.0531**
Smt-smt	Pred	1.051	1.034	1.010				0.8826
Est-ocn	Pred				1.000		1.000	0.0752
Adt-adt	Pred					1.000		0.8360
Smt-adt	Pred							**0.0555**
Smt-smt	Est	1.051	1.034	1.010				0.8826
Est-ocn	Est				1.057		1.000	0.0795
Adt-adt	Est					1.000		0.8360
Smt-adt	Est							**0.0587**
Smt-smt	Harv	1.051	1.034	1.010				0.8826
Est-ocn	Harv				1.057		1.000	0.0795
Adt-adt	Harv					1.000		0.8360
Smt-adt	Harv							**0.0587**
Smt-smt	MarLow	1.051	1.034	1.010				0.8826
Est-ocn	MarLow				1.057		0.750	0.0596
Adt-adt	MarLow					1.000		0.8360
Smt-adt	MarLow							**0.0440**
Smt-smt	MarHigh	1.051	1.034	1.010				0.8826
Est-ocn	MarHigh				1.057		1.250	0.0994
Adt-adt	MarHigh					1.000		0.8360
Smt-adt	MarHigh							**0.0733**

Table H-12. Out-of-subbasin survival rates applied in AHA modeling for baseline (B), current (C), and prospective future action scenarios for John Day River summer steelhead populations. Future action scenarios were modeled sequentially, where hydro (Hyd) actions were added to current conditions, predation (Pred) actions were added to hydro, estuarine (Est) actions were added to predation, and harvest (Harv) actions were added to estuarine. Decreased (MarLow) and increased (MarHigh) marine survival rate scenarios were then added to the combined prospective future action scenarios.

Life stage	Scen	Survival multiplier by factor						Scen surv
		Hydro	Avian	Pikemin	Estuary	Harvest	Marine	
Smt-smt	B							0.5850
Est-ocn	B							0.0750
Adt-adt	B							0.7526
Smt-adt	B							**0.0330**
Smt-smt	C	1.103	0.997	1.000				0.6433
Est-ocn	C				1.003		1.000	0.0752
Adt-adt	C					1.043		0.7849
Smt-adt	C							**0.0380**
Smt-smt	Hyd	1.100	1.000	1.000				0.7077
Est-ocn	Hyd				1.000		1.000	0.0752
Adt-adt	Hyd					1.000		0.7849
Smt-adt	Hyd							**0.0418**
Smt-smt	Pred	1.100	1.034	1.010				0.7390
Est-ocn	Pred				1.000		1.000	0.0752
Adt-adt	Pred					1.000		0.7849
Smt-adt	Pred							**0.0436**
Smt-smt	Est	1.100	1.034	1.010				0.7390
Est-ocn	Est				1.057		1.000	0.0795
Adt-adt	Est					1.000		0.7849
Smt-adt	Est							**0.0461**
Smt-smt	Harv	1.100	1.034	1.010				0.7390
Est-ocn	Harv				1.057		1.000	0.0795
Adt-adt	Harv					1.000		0.7849
Smt-adt	Harv							**0.0461**
Smt-smt	MarLow	1.100	1.034	1.010				0.7390
Est-ocn	MarLow				1.057		0.750	0.0596
Adt-adt	MarLow					1.000		0.7849
Smt-adt	MarLow							**0.0346**
Smt-smt	MarHigh	1.100	1.034	1.010				0.7390
Est-ocn	MarHigh				1.057		1.250	0.0994
Adt-adt	MarHigh					1.000		0.7849
Smt-adt	MarHigh							**0.0577**

Table H-13. Out-of-subbasin survival rates applied in AHA modeling for baseline (B), current (C), and prospective future action scenarios for Umatilla River summer steelhead. Future action scenarios were modeled sequentially, where hydro (Hyd) actions were added to current conditions, predation (Pred) actions were added to hydro, estuarine (Est) actions were added to predation, and harvest (Harv) actions were added to estuarine. Decreased (MarLow) and increased (MarHigh) marine survival rate scenarios were then added to the combined prospective future action scenarios.

Life stage	Scen	Survival multiplier by factor						Scen surv
		Hydro	Avian	Pikemin	Estuary	Harvest	Marine	
Smt-smt	B							0.5850
Est-ocn	B							0.0750
Adt-adt	B							0.7577
Smt-adt	B							**0.0332**
Smt-smt	C	1.103	1.000	0.997				0.6433
Est-ocn	C				1.003		1.000	0.0752
Adt-adt	C					1.043		0.7902
Smt-adt	C							**0.0382**
Smt-smt	Hyd	1.100	1.000	1.000				0.7077
Est-ocn	Hyd				1.000		1.000	0.0752
Adt-adt	Hyd					1.000		0.7902
Smt-adt	Hyd							**0.0421**
Smt-smt	Pred	1.100	1.034	1.010				0.7390
Est-ocn	Pred				1.000		1.000	0.0752
Adt-adt	Pred					1.000		0.7902
Smt-adt	Pred							**0.0439**
Smt-smt	Est	1.100	1.034	1.010				0.7390
Est-ocn	Est				1.057		1.000	0.0795
Adt-adt	Est					1.000		0.7902
Smt-adt	Est							**0.0464**
Smt-smt	Harv	1.100	1.034	1.010				0.7390
Est-ocn	Harv				1.057		1.000	0.0795
Adt-adt	Harv					1.000		0.7902
Smt-adt	Harv							**0.0464**
Smt-smt	MarLow	1.100	1.034	1.010				0.7390
Est-ocn	MarLow				1.057		0.750	0.0596
Adt-adt	MarLow					1.000		0.7902
Smt-adt	MarLow							**0.0348**
Smt-smt	MarHigh	1.100	1.034	1.010				0.7390
Est-ocn	MarHigh				1.057		1.250	0.0994
Adt-adt	MarHigh					1.000		0.7902
Smt-adt	MarHigh							**0.0580**

Table H-14. Out-of-subbasin survival rates applied in AHA modeling for baseline (B), current (C), and prospective future action scenarios for Walla Walla River summer steelhead. Future action scenarios were modeled sequentially, where hydro (Hyd) actions were added to current conditions, predation (Pred) actions were added to hydro, estuarine (Est) actions were added to predation, and harvest (Harv) actions were added to estuarine. Decreased (MarLow) and increased (MarHigh) marine survival rate scenarios were then added to the combined prospective future action scenarios.

Life stage	Scen	Survival multiplier by factor						Scen surv
		Hydro	Avian	Pikemin	Estuary	Harvest	Marine	
Smt-smt	B							0.5150
Est-ocn	B							0.0750
Adt-adt	B							0.6818
Smt-adt	B							**0.0263**
Smt-smt	C	1.143	0.997	1.000				0.5869
Est-ocn	C				1.003		1.000	0.0752
Adt-adt	C					1.043		0.7111
Smt-adt	C							**0.0314**
Smt-smt	Hyd	1.122	1.000	1.000				0.6585
Est-ocn	Hyd				1.000		1.000	0.0752
Adt-adt	Hyd					1.000		0.7111
Smt-adt	Hyd							**0.0352**
Smt-smt	Pred	1.122	1.034	1.010				0.6877
Est-ocn	Pred				1.000		1.000	0.0752
Adt-adt	Pred					1.000		0.7111
Smt-adt	Pred							**0.0368**
Smt-smt	Est	1.122	1.034	1.010				0.6877
Est-ocn	Est				1.057		1.000	0.0795
Adt-adt	Est					1.000		0.7111
Smt-adt	Est							**0.0389**
Smt-smt	Harv	1.122	1.034	1.010				0.6877
Est-ocn	Harv				1.057		1.000	0.0795
Adt-adt	Harv					1.000		0.7111
Smt-adt	Harv							**0.0389**
Smt-smt	MarLow	1.122	1.034	1.010				0.6877
Est-ocn	MarLow				1.057		0.750	0.0596
Adt-adt	MarLow					1.000		0.7111
Smt-adt	MarLow							**0.0292**
Smt-smt	MarHigh	1.122	1.034	1.010				0.6877
Est-ocn	MarHigh				1.057		1.250	0.0994
Adt-adt	MarHigh					1.000		0.7111
Smt-adt	MarHigh							**0.0486**

Part 2: Summaries of Diagnostic Reports

A series of graphic reports are presented here giving additional information about the predicted outcomes of the subbasin habitat scenarios analyzed in Section 10. These reports are extracted from output produced by EDT.

Summaries from three different EDT reports are provided for each steelhead population. The first report—the Baseline Diagnostic Report—summarizes basic diagnostic information for each population under baseline habitat conditions within the relevant subbasin. It is based on a comparison of habitat conditions within the baseline period to the pre-development state (see Lichatowich et al. 1995). Some of this information served as the basis of parts of the diagnostic summaries described in Section 8 of this report. The baseline diagnostic report serves here to help illustrate—in conjunction the other reports described below—the extent that subbasin habitat factors responsible for changes in population performance are expected to be affected by the proposed habitat scenarios. It shows the relative extent that population performance has been affected by habitat changes (due to land and water uses) within each individual stream reach or geographic area within the subbasin.[2] One aspect of the report displays the potential benefits of full restoration or full protection (i.e., avoiding future habitat degradation) for each stream reach or geographic area. This report (together with a more detailed presentation in the full EDT output) summarizes the limiting factors analysis produced by the EDT model.

The second report—the Scenario Profile Report—summarizes the extent of changes to the habitat factors expected to result from a habitat action scenario once implemented within a subbasin. It identifies the relative gain (or loss in some cases) in population performance that would occur as a result of the scenario's effect within the subbasin. The extent of changes to population performance are shown for the scenario's effects within each stream reach or geographic area.

The third report—the Scenario Diagnostic Report—is like the baseline diagnostic report, only instead of comparing the baseline to the pre-development state, it compares the habitat scenario to the pre-development condition. It identifies the geographic areas and habitat factors that would be expected to still be inhibiting population performance after action implementation relative to the pre-development habitat condition. The report is essentially a limiting factors analysis of the habitat as it is predicted to exist following implementation and maturation of effects of the habitat scenario. As such, it helps identify areas/factors where additional habitat actions might be considered. Hence, it can serve to further refine proposed actions as a part of future planning efforts.

Each report consists of two figures. The first one is a "tornado chart" displaying the potential benefits from restoration or protection actions—or in the case of the Scenario Profile Report the

[2] / The spatial scale used in this report was defined by the individuals who did the original EDT analysis for subbasin planning. In some cases, individuals grouped stream reaches into geographic areas for the sake of simplifying the diagnosis. In some subbasins, reaches were not grouped in such a manner. The graphic reports presented in this appendix employ whatever scale was used in subbasin planning. For definitions of stream reaches or geographic areas, see the appropriate subbasin report.

relative gain/loss of the habitat scenario. Geographic areas near the top of the chart offer the highest potential for gain in performance (or that would result in the highest gain in the Scenario Profile Report). The charts show an assigned level of benefit, listed as A through E, where A areas are those the greatest amount of benefit and D and E provide essentially no benefit. The charts also show the expectation of amount of benefit/loss in population performance as the percentage of increase or decrease in a particular performance measure. (See Section 10 for definitions of performance measures.)

Each tornado chart is followed by a second figure giving a summary of the diagnostics for the various habitat factors affecting survival within each stream reach or geographic area. This chart summarizes where and what factors are most responsible for the loss in population performance. For the Scenario Profile Report, it shows the relative extent that each factor is expected to be affected by the scenario as pertaining to population performance. The chart is meant only to be a summary snapshot of the effects of each factor (or the effects on each factor for the Scenario Profile Report).

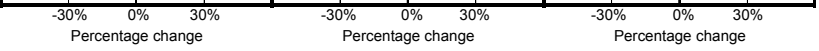
Results for the habitat scenario consisting of all subbasin actions (both Priority 1 and 2) at 100 years are presented. For the Deschutes westside population, results are shown passage provided at the Pelton-Round Butte Complex.

Baseline Diagnostic Report – Tornado Chart

Fifteenmile Creek Winter Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Eightmile Cr-8	A	5	A	5						
Ramsey Cr-4	A	1	B	15						
Fifteenmile Cr-9	B	11	A	6						
Fivemile Cr-4	B	14	A	3						
Ramsey Cr-3	B	9	B	10						
Eightmile Cr-10	A	5	C	17						
Fivemile Cr-3	D	23	A	1						
Fifteenmile Cr-12	A	2	C	23						
Fifteenmile Cr-8	C	18	B	8						
Fifteenmile Cr-11	B	10	C	18						
Fifteenmile Cr-7	D	21	B	7						
Fifteenmile Cr-5	E	28	A	2						
Fifteenmile Cr-13	A	3	C	28						
Fivemile Cr MF-1	B	7	C	26						
Eightmile Cr-7	B	8	C	26						
Fifteenmile Cr-3	D	23	B	13						
Ramsey Cr-1	D	20	B	16						
Eightmile Cr-6	E	33	A	4						
Fifteenmile Cr-14	A	3	D	34						
Fivemile Cr-1	E	27	B	12						
Fifteenmile Cr-6	E	30	B	11						
Fifteenmile Cr-4	E	36	B	9						
Eightmile Cr-3	E	33	B	14						
Eightmile Cr-9	C	16	D	32						
Fifteenmile Cr-10	C	17	D	31						
Fifteenmile Cr-16	B	12	D	36						
Fivemile Cr-2	E	30	C	19						
Eightmile Cr-4	E	26	C	25						
Cedar Cr	B	14	D	38						
Ramsey Cr-2	C	19	D	33						
Fifteenmile Cr-15	B	13	D	40						
Eightmile Cr-5	E	37	C	21						
Eightmile Cr-13	E	41	C	19						
Eightmile Cr-2	E	38	C	22						
Dry Cr-2	E	40	C	23						
Eightmile Cr-1	E	35	C	28						
Fivemile Cr SF-1	D	22	E	44						
Ramsey Cr-6	D	25	E	41						
Dry Cr-1	E	39	C	28						
Fifteenmile Cr-1	E	29	D	39						
Eightmile Cr-12	E	32	E	41						
Ramsey Cr-7	E	41	D	35						
Fivemile Cr MF-2	E	41	D	37						
Ramsey Cr-5	E	41	E	43						
Eightmile Cr-11	E	41	E	45						
Eightmile Cr-14	E	41	E	45						
Fifteenmile Cr-2	E	41	E	45						
Fivemile Cr MF-3	E	41	E	45						
Ramsey Cr-8	E	41	E	45						



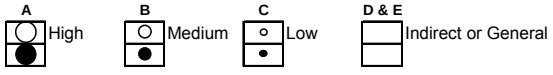
Baseline Diagnostic Report – Diagnostic Summary

Fifteenmile Creek Winter Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Fifteenmile Cr-1							●		•			•	●	•	•	●		•
Fifteenmile Cr-2																		
Fifteenmile Cr-3		○	•				●	•	●	•		●	●		●	●		•
Eightmile Cr-1		○	•		•		●	•	●	•			●		●	●		•
Fivemile Cr-1		○	●		•		●	•	●	●			●			●		●
Fivemile Cr-2		○	●				●	•	●	•			●	•		●	●	●
Fivemile Cr-3		◯	●		•		●	•	●	●			●	•		●	●	●
Fivemile Cr-4	○	◯	•				•		●	•					●	•		•
Fivemile Cr SF-1							•		•									•
Fivemile Cr MF-1	○	○	•				•		•									●
Fivemile Cr MF-2											●							
Fivemile Cr MF-3			•				•		•									
Eightmile Cr-2		○	●		•		●	•	●	•			●	•	●	●		●
Eightmile Cr-3		○	●		•		●	•	●	•			●		●	●		•
Eightmile Cr-4		○	●				●	•	●	•			•		●	●		●
Eightmile Cr-5		○	•		•		●	•	●	•			●		●	●		•
Eightmile Cr-6		◯	●		•		●	•	●	•			●		●	●		•
Eightmile Cr-7	○	○	●				•	•	•	•						•		•
Eightmile Cr-8	◯	◯	•				•	•	●						●			•
Eightmile Cr-9	○		•				•		•						●			•
Eightmile Cr-10	◯	○	•				•		•						●			●
Eightmile Cr-11																		
Eightmile Cr-12			•				•		•						●			●
Eightmile Cr-13		○									●							
Eightmile Cr-14							•		•						●			●
Fifteenmile Cr-4		○	•		•		●	•	●	•		●	●		●	●		•
Fifteenmile Cr-5		◯	•		•		●	•	●	•		●	●		●	●		•
Fifteenmile Cr-6		○	•		•		●	•	●	•		•	●		●	●		•
Dry Cr-1		○	•		•		●	•	●	•			●		●	●		●
Dry Cr-2		○	•		•		●	•	●				●	•		●		●
Fifteenmile Cr-7		○	•		•		●	•	●	•			●		●	●		•
Fifteenmile Cr-8	○	○	•		•		•	•	●	•			●			●		•
Ramsey Cr-1		○	•				●	•	●	•			•		●	●		•
Ramsey Cr-2	○		•				●	•	●	•					●	•		●
Ramsey Cr-3	○	○	•				•		•						●			●
Ramsey Cr-4	◯	○					•		•									
Ramsey Cr-5											●							
Ramsey Cr-6			•				•		●						●			•
Ramsey Cr-7											●							
Ramsey Cr-8			●				•		•						●			●
Fifteenmile Cr-9	○	◯	●		•		•	•	●	•					●	●		•
Fifteenmile Cr-10	○		●				•		•						●	•		•
Fifteenmile Cr-11	○	○	●				•		•						●	•		•
Fifteenmile Cr-12	◯	○																•
Fifteenmile Cr-13	◯	○							•									•
Cedar Cr	○		•				•		•									•
Fifteenmile Cr-14	◯								•									•
Fifteenmile Cr-15	○																	•
Fifteenmile Cr-16	○		•						•									•

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Fifteenmile Creek Winter Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Fifteenmile Cr-4	C	1	B	9						
Fivemile Cr-3	E	14	A	1						
Fivemile Cr-4	E	14	A	2						
Eightmile Cr-8	E	14	A	3						
Eightmile Cr-6	E	14	A	4						
Fifteenmile Cr-5	E	14	A	4						
Fifteenmile Cr-3	C	3	C	16						
Eightmile Cr-13	D	7	C	13						
Fifteenmile Cr-9	E	14	A	6						
Fivemile Cr-1	C	5	C	15						
Fifteenmile Cr-8	E	14	B	7						
Fifteenmile Cr-7	E	14	B	8						
Eightmile Cr-1	C	2	C	21						
Fifteenmile Cr-6	E	14	B	9						
Eightmile Cr-4	C	4	C	21						
Eightmile Cr-5	C	6	C	19						
Ramsey Cr-1	E	14	C	11						
Ramsey Cr-3	E	14	C	11						
Fifteenmile Cr-11	E	14	C	13						
Eightmile Cr-3	E	14	C	17						
Eightmile Cr-10	E	14	C	18						
Eightmile Cr-2	D	9	C	24						
Eightmile Cr-7	E	14	C	20						
Fivemile Cr-2	D	8	C	26						
Dry Cr-1	E	10	C	25						
Fifteenmile Cr-10	E	14	C	21						
Dry Cr-2	E	11	C	27						
Ramsey Cr-4	E	14	C	27						
Fifteenmile Cr-12	E	14	D	29						
Eightmile Cr-9	E	14	D	30						
Fivemile Cr MF-1	E	14	D	31						
Ramsey Cr-2	E	14	D	32						
Fifteenmile Cr-1	E	12	D	35						
Fifteenmile Cr-13	E	14	D	33						
Fifteenmile Cr-14	E	14	D	34						
Fifteenmile Cr-16	E	14	D	36						
Eightmile Cr-12	E	14	D	37						
Ramsey Cr-5	E	13	E	38						
Cedar Cr	E	14	E	39						
Fifteenmile Cr-15	E	14	E	39						
Ramsey Cr-6	E	14	E	39						
Fivemile Cr SF-1	E	14	E	42						
Eightmile Cr-11	E	14	E	43						
Eightmile Cr-14	E	14	E	43						
Fifteenmile Cr-2	E	14	E	43						
Fivemile Cr MF-2	E	14	E	43						
Fivemile Cr MF-3	E	14	E	43						
Ramsey Cr-7	E	14	E	43						
Ramsey Cr-8	E	14	E	43						

-20% 0% 20%
Percentage change

-20% 0% 20%
Percentage change

-20% 0% 20%
Percentage change

Scenario Profile Report – Change in Habitat Factors Summary

Priority 1 and 2 Subbasin Actions – 100 years

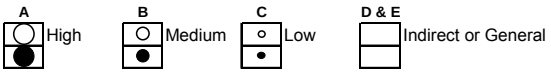
Fifteenmile Creek Winter Steelhead

Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario																
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Fifteenmile Cr-1							○		∘			○	∘		∘	○		
Fifteenmile Cr-2									∘									
Fifteenmile Cr-3	•	∘	∘				○		○	∘		○	○		◯	◯		
Eightmile Cr-1	•	∘	∘		∘		◯	∘	○	∘			○		○	◯		
Fivemile Cr-1	•	∘	○		∘		○		○	∘			∘			◯		◯
Fivemile Cr-2		∘	○				○		◯	∘			○			◯		◯
Fivemile Cr-3		◯	○		∘		○	∘	○	○			○	∘		◯		◯
Fivemile Cr-4		◯	∘				∘		○	∘					○	∘		∘
Fivemile Cr SF-1							∘		∘									∘
Fivemile Cr MF-1			∘				∘		∘									○
Fivemile Cr MF-2																		
Fivemile Cr MF-3			∘															•
Eightmile Cr-2		∘	○		∘		◯	∘	○	∘			○		◯	◯		◯
Eightmile Cr-3		∘	○		∘		○	∘	◯	∘			○		◯	◯		
Eightmile Cr-4	•	∘	○				○		○	∘			∘		◯	◯		◯
Eightmile Cr-5	•	∘	∘		∘		○	∘	○	∘			∘		◯	◯		
Eightmile Cr-6		◯	○		∘		○	∘	○	∘		∘	○		◯	◯		
Eightmile Cr-7		∘	○				∘		∘	∘						∘		
Eightmile Cr-8		◯	○				∘		○						○			
Eightmile Cr-9			○				∘		∘						○			∘
Eightmile Cr-10		∘	∘				∘		∘						○			∘
Eightmile Cr-11																		
Eightmile Cr-12			∘				∘		∘						◯			∘
Eightmile Cr-13		∘									◯							
Eightmile Cr-14							∘		∘						◯			∘
Fifteenmile Cr-4	•	○	∘		∘		○	∘	○	∘		○	○		◯	◯		
Fifteenmile Cr-5		◯	∘		∘		○	∘	○	∘		○	∘		○	◯		∘
Fifteenmile Cr-6		○	∘		∘		○	∘	○	∘		∘	○		○	◯		∘
Dry Cr-1		∘	∘				○		○	∘			∘		○	◯		∘
Dry Cr-2		∘	∘				○		◯				○			◯		∘
Fifteenmile Cr-7		○	∘		∘		○	∘	○	∘			∘		○	◯		
Fifteenmile Cr-8		○	∘		∘		∘	∘	○	∘		∘	∘			◯		
Ramsey Cr-1		∘	∘				○		○	∘					○	◯		
Ramsey Cr-2			∘				∘		○	∘					◯	∘		○
Ramsey Cr-3		∘					∘		∘						○			○
Ramsey Cr-4		∘																•
Ramsey Cr-5											◯							
Ramsey Cr-6							∘		∘						○			•
Ramsey Cr-7																		
Ramsey Cr-8			○				∘		∘						○			∘
Fifteenmile Cr-9		◯	○		∘		∘	∘	○	∘		∘			○	◯		
Fifteenmile Cr-10		∘	○				∘		○						○	∘		
Fifteenmile Cr-11		∘	∘				∘		∘						◯	∘		
Fifteenmile Cr-12																		∘
Fifteenmile Cr-13																		
Cedar Cr			∘						∘									∘
Fifteenmile Cr-14																		∘
Fifteenmile Cr-15																		∘
Fifteenmile Cr-16																		∘

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown



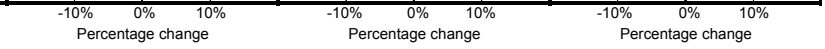
Scenario Diagnostic Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Fifteenmile Creek Winter Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Eightmile Cr-8	A	1	A	1						
Fifteenmile Cr-5	B	2	B	7						
Fifteenmile Cr-9	B	3	A	6						
Fivemile Cr-3	B	4	B	8						
Ramsey Cr-4	B	8	A	4						
Fivemile Cr-4	B	5	B	11						
Fifteenmile Cr-4	B	12	A	5						
Ramsey Cr-3	B	15	A	2						
Fifteenmile Cr-7	B	8	B	13						
Eightmile Cr-10	B	6	B	17						
Eightmile Cr-6	B	6	B	19						
Fifteenmile Cr-12	B	10	B	15						
Fifteenmile Cr-3	C	23	A	2						
Fifteenmile Cr-8	B	12	B	15						
Fivemile Cr-1	C	21	B	9						
Eightmile Cr-3	C	22	B	10						
Fifteenmile Cr-13	C	20	B	12						
Fivemile Cr MF-1	B	15	B	17						
Eightmile Cr-14	B	10	C	25						
Fifteenmile Cr-6	B	14	C	21						
Fifteenmile Cr-14	C	17	C	22						
Fifteenmile Cr-11	C	19	C	27						
Ramsey Cr-1	C	24	C	24						
Eightmile Cr-4	C	27	C	23						
Eightmile Cr-5	C	24	C	26						
Eightmile Cr-7	C	18	D	36						
Fivemile Cr-2	D	36	B	19						
Ramsey Cr-7	E	42	B	14						
Eightmile Cr-2	C	28	D	30						
Eightmile Cr-9	C	26	D	32						
Dry Cr-1	C	30	D	29						
Dry Cr-2	C	28	D	31						
Eightmile Cr-1	D	33	D	32						
Fifteenmile Cr-16	D	33	D	34						
Fifteenmile Cr-10	C	31	D	37						
Fivemile Cr MF-2	E	42	C	27						
Fifteenmile Cr-15	C	31	D	40						
Ramsey Cr-2	D	37	D	35						
Cedar Cr	D	35	D	40						
Fifteenmile Cr-1	D	39	D	39						
Ramsey Cr-6	E	41	D	37						
Eightmile Cr-12	D	38	E	43						
Fivemile Cr SF-1	E	40	E	42						
Eightmile Cr-11	E	42	E	44						
Eightmile Cr-13	E	42	E	44						
Fifteenmile Cr-2	E	42	E	44						
Fivemile Cr MF-3	E	42	E	44						
Ramsey Cr-5	E	42	E	44						
Ramsey Cr-8	E	42	E	44						



Scenario Diagnostic Report – Diagnostic Summary

Priority 1 and 2 Subbasin Actions – 100 years

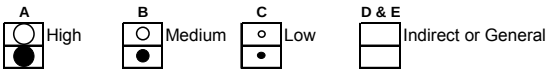
Fifteenmile Creek Winter Steelhead

Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Fifteenmile Cr-1							●									●		
Fifteenmile Cr-2																		
Fifteenmile Cr-3	○	◯					●		●							●		●
Eightmile Cr-1							●									●		●
Fivemile Cr-1	○	○	●				●		●	●						●		●
Fivemile Cr-2		○	●				●		●							●	●	●
Fivemile Cr-3	○	○					●										●	●
Fivemile Cr-4	○	○							●									●
Fivemile Cr SF-1									●									●
Fivemile Cr MF-1	○	○	●						●									●
Fivemile Cr MF-2		○									◯							
Fivemile Cr MF-3			●						●									●
Eightmile Cr-2	○		●				●									●		●
Eightmile Cr-3	○	○	●				●		●							●		●
Eightmile Cr-4	○	○	●				●		●							●		●
Eightmile Cr-5	○	○					●		●	●						●		●
Eightmile Cr-6	○	○	●				●		●							●		●
Eightmile Cr-7	○																	
Eightmile Cr-8	◯	◯																
Eightmile Cr-9	○																	
Eightmile Cr-10	○	○																●
Eightmile Cr-11																		
Eightmile Cr-12																		●
Eightmile Cr-13																		
Eightmile Cr-14	○	○																●
Fifteenmile Cr-4	○	◯					●		●	●						●		●
Fifteenmile Cr-5	○	○					●		●	●						●		●
Fifteenmile Cr-6	○	○					●		●							●		●
Dry Cr-1	○						●		●	●			●			●		●
Dry Cr-2	○						●		●							●		●
Fifteenmile Cr-7	○	○					●		●							●		●
Fifteenmile Cr-8	○	○							●							●		●
Ramsey Cr-1	○	○	●				●		●	●						●		●
Ramsey Cr-2							●		●						●			●
Ramsey Cr-3	○	◯					●		●						●			●
Ramsey Cr-4	○	◯					●		●									
Ramsey Cr-5																		
Ramsey Cr-6							●		●						●			●
Ramsey Cr-7		○									◯							
Ramsey Cr-8			●				●		●						●			●
Fifteenmile Cr-9	○	◯	●															●
Fifteenmile Cr-10	○		●															●
Fifteenmile Cr-11	○	○	●															
Fifteenmile Cr-12	○	○																
Fifteenmile Cr-13	○	○							●									●
Cedar Cr			●						●									●
Fifteenmile Cr-14	○	○																●
Fifteenmile Cr-15	○																	●
Fifteenmile Cr-16																		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

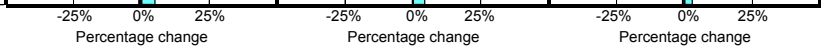


Baseline Diagnostic Report – Tornado Chart

Deschutes Eastside Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
L Deschutes MS-17	A	1	A	6						
L Deschutes MS-16	A	2	A	13						
Trout Cr-5	B	10	A	9						
L Deschutes MS-18	B	5	B	16						
Buck Hollow Cr-1	C	23	A	1						
Buck Hollow Cr-3	C	26	A	3						
Trout Cr-12	B	6	B	24						
Thorn Hollow	C	25	A	8						
Deep Cr-2 (Bakeoven)	D	30	A	5						
L Deschutes MS-15	A	3	C	33						
L Deschutes MS-6	D	33	A	4						
L Deschutes MS-12	B	8	C	30						
L Deschutes MS-14	C	14	C	28						
L Deschutes MS-8	D	32	A	13						
L Deschutes MS-13	B	10	C	37						
Deep Cr-1 (Bakeoven)	D	36	A	12						
Foley Cr-2	C	13	C	35						
L Deschutes MS-19	A	4	C	45						
Bakeoven Cr-1	C	17	C	33						
Buck Hollow Cr-4	D	30	B	21						
Ward Cr-1	D	29	B	22						
Trout Cr-13	B	9	C	43						
Deep Cr-3 (Bakeoven)	D	28	B	25						
Trout Cr-14	B	7	C	47						
Buck Hollow Cr-2	D	42	B	15						
Little Trout Cr	D	38	B	25						
Trout Cr-11	C	24	C	40						
Dutchman Cr	C	15	D	50						
Bakeoven Cr-4	E	57	A	10						
Bakeoven Cr-3	E	47	B	22						
Cartwright Cr	C	18	D	52						
Foley Cr-1	C	19	D	53						
Cottonwood Cr-1	E	54	B	19						
Trout Cr-7	E	66	A	7						
Potlid Cr	C	12	D	63						
Board Hollow Cr	C	21	D	55						
Trout Cr-15	C	16	D	64						
Trout Cr-3	E	78	A	2						
L Deschutes MS-5	E	51	C	32						
Bakeoven Cr-2	E	49	C	36						
Trout Cr-6	E	75	A	11						
Big Log Cr-2	D	27	D	62						
Tenmile Cr	E	61	C	28						
L Deschutes MS-4	C	22	E	70						
Auger Cr	D	33	D	60						
Amity Cr	E	75	B	19						
Beaver Cr (Trout)	D	37	D	57						
Clover Cr	D	44	D	51						
Trout Cr-8	E	78	B	17						
Trout Cr-4	E	69	C	27						
L Deschutes MS-7	E	55	C	42						



Continued next page

Deschutes Eastside Summer Steelhead - continued

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Maupin Trail Canyon	E	49	D	48						
Nena Cr-1	D	42	D	55						
L Deschutes MS-2	C	20	E	78						
Wapinitia Cr-1	D	35	E	65						
Opal Cr-2	E	62	C	40						
Antelope Cr-4	E	87	B	17						
Big Log Cr-1	D	38	E	67						
Trout Cr-9	E	70	C	37						
Big Whetstone Cr	E	48	D	60						
Warm Springs MS-1	D	41	E	67						
Antelope Cr-1	E	70	C	39						
L Deschutes MS-11	D	40	E	73						
Stag Canyon	D	44	E	69						
Opal Cr-1	E	56	D	58						
Trout Cr-1	E	70	D	49						
Mud Springs Cr-1	E	66	D	54						
Antelope Cr-2	E	90	C	31						
Skookum Cr	E	46	E	75						
Trout Cr-2	E	78	C	43						
Eagle Cr	E	59	E	66						
Cottonwood Cr-2	E	70	D	59						
Hauser Canyon	E	60	E	72						
Trout Cr-10	E	90	C	46						
L Deschutes MS-1	E	51	E	87						
Ferry Canyon	E	68	E	71						
L Deschutes MS-3	E	53	E	86						
Buck Hollow Cr-5	E	64	E	81						
Finnegan Canyon	E	65	E	80						
L Deschutes MS-9	E	58	E	87						
Macken Canyon	E	62	E	83						
Oak Canyon	E	70	E	78						
Bakeoven Cr-5	E	84	E	74						
Macks Canyon	E	78	E	81						
Trout Cr-16	E	77	E	84						
Hay Cr-1	E	89	E	76						
Mud Springs Cr-2	E	90	E	76						
Robin Cr	E	78	E	91						
Fall Canyon	E	85	E	89						
Jones Canyon	E	90	E	85						
Tub Springs Canyon	E	78	E	97						
L Deschutes MS-20	E	86	E	92						
Booten Cr	E	90	E	90						
Mud Springs Cr-3	E	87	E	95						
Trail Hollow Cr	E	90	E	93						
Hay Cr-2	E	90	E	94						
Mud Springs Cr-4	E	90	E	96						
Antelope Cr-3	E	90	E	97						
Hay Cr-3	E	90	E	97						
L Deschutes MS-10	E	90	E	97						
Mud Springs Cr-5	E	90	E	97						
Mud Springs Cr-6	E	90	E	97						
Ochoco Gulch Cr	E	90	E	97						
Sagebrush Cr	E	90	E	97						
White R MS-1	E	90	E	97						

-25% 0% 25%
Percentage change

-25% 0% 25%
Percentage change

-25% 0% 25%
Percentage change

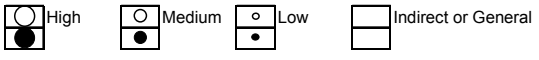
Baseline Diagnostic Report – Diagnostic Summary

Deschutes Eastside Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
L Deschutes MS-1					●				●					●				●
L Deschutes MS-2	○				●				●					●				●
Fall Canyon							●		●									●
L Deschutes MS-3					●				●					●				
L Deschutes MS-4	○				●		●		●					●				
Macks Canyon			●				●		●									●
L Deschutes MS-5		○			●		●		●					●	●	●		
Ferry Canyon							●		●						●			●
L Deschutes MS-6		◯			●		●		●					●	●			
Jones Canyon			●				●		●									●
L Deschutes MS-7		○			●		●		●					●	●			
Oak Canyon			●				●		●									●
L Deschutes MS-8		◯			●		●		●					●	●			
Buck Hollow Cr-1	○	◯	●				●		●					●	●	●		●
Finnegan Canyon			●				●		●						●			●
Buck Hollow Cr-2		○	●				●		●					●	●	●		●
Hauser Canyon							●		●									●
Buck Hollow Cr-3	○	◯	●				●		●				●	●		●		●
Macken Canyon							●		●									
Buck Hollow Cr-4		○	●				●		●					●		●		●
Thorn Hollow	○	◯	●				●		●					●		●		●
Buck Hollow Cr-5							●		●					●		●		●
L Deschutes MS-9					●		●		●									●
L Deschutes MS-10																		
L Deschutes MS-11					●				●					●				●
White R MS-1							●		●					●				●
L Deschutes MS-12	◯	○	●		●		●		●					●				
Bakeoven Cr-1	○	○	●				●		●					●		●		●
Trail Hollow Cr			●				●		●									●
Bakeoven Cr-2		○	●				●		●					●		●		●
Booten Cr			●				●		●							●		●
Bakeoven Cr-3		○	●				●		●					●		●		●
Robin Cr			●				●		●									●
Bakeoven Cr-4		◯	●				●		●				●	●		●		●
Deep Cr-1 (Bakeoven)		◯	●				●		●				●	●		●		●
Cottonwood Cr-1		○	●				●		●				●	●		●		●
Ochoco Gulch Cr							●		●							●		●
Cottonwood Cr-2			●				●		●					●		●		●
Deep Cr-2 (Bakeoven)		◯	●				●		●				●	●		●		●
Maupin Trail Canyon			●				●		●				●	●		●		
Deep Cr-3 (Bakeoven)		○	●				●		●				●	●		●		●
Bakeoven Cr-5			●				●		●					●		●		●
L Deschutes MS-13	◯	○	●		●		●		●	●			●	●		●		
Stag Canyon			●				●		●				●	●		●		
L Deschutes MS-14	○	○	●		●		●		●					●				●
Wapinitia Cr-1							●		●					●	●			●
L Deschutes MS-15	◯	○			●		●		●					●				
Nena Cr-1			●				●		●					●		●		●
L Deschutes MS-16	◯	◯					●		●									
Eagle Cr			●				●		●					●		●		●
L Deschutes MS-17	◯	◯	●		●		●		●					●				
Skookum Cr							●		●							●		●
L Deschutes MS-18	○	○	●		●		●		●					●				
Warm Springs MS-1					●		●		●				●					
L Deschutes MS-19	◯	○			●		●		●					●				
Trout Cr-1			●				●		●					●		●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Continued next page

Deschutes Eastside Summer Steelhead - continued
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Tenmile Cr		○	●				●		●					●		●		●
Trout Cr-2		○	●				●		●					●		●		●
Mud Springs Cr-1			●				●		●					●	●	●		
Mud Springs Cr-2											●							
Mud Springs Cr-3			●				●		●					●	●	●		
Sagebrush Cr			●				●		●									
Mud Springs Cr-4			●				●		●					●	●	●		
Mud Springs Cr-5																		
Mud Springs Cr-6			●				●		●					●	●	●		
Trout Cr-3		◯	●				●		●				●	●	●	●		●
Hay Cr-1			●				●		●	●			●	●		●		●
Hay Cr-2											●							
Hay Cr-3			●				●		●	●			●	●		●		●
Trout Cr-4		○	●				●		●				●	●		●		●
Antelope Cr-1		○	●				●		●				●	●		●		●
Ward Cr-1		◯	●				●		●					●		●		
Antelope Cr-2		○	●				●		●				●	●	●	●		
Antelope Cr-3																		
Antelope Cr-4		◯	●				●		●				●	●	●	●		●
Trout Cr-5	◯	◯	●				●		●					●		●		●
Tub Springs Canyon							●		●							●		●
Trout Cr-6		◯	●				●		●				●	●		●		●
Little Trout Cr		◯	●				●		●					●	●	●		●
Trout Cr-7		◯	●				●		●				●	●	●	●		●
Big Whetstone Cr			●				●		●					●		●		
Trout Cr-8		◯	●				●		●				●	●	●	●		●
Clover Cr			●				●		●					●		●		
Trout Cr-9		○	●				●		●				●	●	●	●		●
Beaver Cr (Trout)			●				●		●					●		●		
Trout Cr-10		○	●				●		●				●	●	●	●		●
Amity Cr		◯	●				●		●				●	●	●	●		●
Trout Cr-11	○	○	●				●		●					●	●	●		
Board Hollow Cr	○		●				●		●					●		●		●
Trout Cr-12	◯	◯	●				●		●					●		●		
Foley Cr-1	○		●				●		●					●		●		
Big Log Cr-1			●				●		●					●		●		
Dutchman Cr	○		●				●		●					●		●		
Big Log Cr-2			●				●		●					●		●		●
Foley Cr-2	○	○	●				●		●					●		●		
Trout Cr-13	◯	○	●				●		●					●		●		
Cartwright Cr	○		●				●		●					●		●		
Trout Cr-14	◯	○	●				●		●					●		●		
Opal Cr-1			●				●		●				●	●		●		
Auger Cr			●				●		●					●		●		
Opal Cr-2		○	●				●		●				●	●		●		
Trout Cr-15	○		●				●		●					●		●		●
Potlid Cr	○		●				●		●					●				●
Trout Cr-16							●		●									●
L Deschutes MS-20									●					●				

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A	B	C	D & E
◯ High	◯ Medium	○ Low	Indirect or General
●	●	●	

Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Eastside Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Loss	Gain	Loss	Gain	Loss	Gain
Buck Hollow Cr-1	E	19	A	1						
Buck Hollow Cr-3	E	19	A	2						
Trout Cr-7	E	19	A	3						
L Deschutes MS-17	E	19	A	4						
Bakeoven Cr-4	E	19	A	5						
Trout Cr-3	E	19	A	6						
Buck Hollow Cr-2	E	19	A	7						
Trout Cr-8	E	19	A	8						
L Deschutes MS-18	E	19	A	9						
Trout Cr-5	E	19	B	10						
Bakeoven Cr-3	E	19	B	11						
Buck Hollow Cr-4	E	19	B	12						
Antelope Cr-4	E	19	B	13						
Deep Cr-2 (Bakeoven)	E	19	B	14						
Trout Cr-12	E	19	B	15						
Thorn Hollow	E	19	B	16						
Antelope Cr-2	E	19	B	17						
Bakeoven Cr-1	E	19	B	17						
Bakeoven Cr-2	E	19	B	17						
Antelope Cr-1	E	19	B	20						
Trout Cr-6	E	19	B	21						
Ward Cr-1	E	19	B	22						
Little Trout Cr	E	19	B	23						
Trout Cr-4	E	19	B	24						
L Deschutes MS-19	E	19	B	25						
Deep Cr-1 (Bakeoven)	E	19	C	26						
Trout Cr-11	E	19	C	27						
Foley Cr-2	E	19	C	28						
Trout Cr-13	E	19	C	29						
Deep Cr-3 (Bakeoven)	E	19	C	30						
Opal Cr-2	E	19	C	30						
Trout Cr-1	E	19	C	32						
Trout Cr-9	E	19	C	33						
Trout Cr-2	E	19	C	34						
Dutchman Cr	E	19	C	35						
Cottonwood Cr-1	E	19	C	36						
Foley Cr-1	E	19	C	37						
Tenmile Cr	E	19	C	38						
Trout Cr-14	E	19	C	39						
Board Hollow Cr	E	19	D	40						
Trout Cr-10	E	19	D	41						
Opal Cr-1	E	19	D	42						
Cartwright Cr	E	19	D	43						
L Deschutes MS-6	E	19	D	44						
Mud Springs Cr-1	E	19	D	44						
L Deschutes MS-4	E	3	E	61						
Beaver Cr (Trout)	E	19	D	46						
Auger Cr	E	19	D	47						
Clover Cr	E	19	D	48						
Mud Springs Cr-2	C	1	E	66						
Trout Cr-15	E	19	D	48						
					-15% 0% 15%		-15% 0% 15%		-15% 0% 15%	
					Percentage change		Percentage change		Percentage change	

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Deschutes Eastside Summer Steelhead - continued

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Maupin Trail Canyon	E	19	D	50						
Amity Cr	E	19	D	51						
L Deschutes MS-7	E	8	E	63						
Nena Cr-1	E	19	D	52						
Potlid Cr	E	19	D	53						
Big Log Cr-2	E	19	E	54						
Bakeoven Cr-5	E	10	E	64						
Big Whetstone Cr	E	19	E	55						
Hay Cr-1	E	2	E	72						
L Deschutes MS-8	E	19	E	56						
Big Log Cr-1	E	19	E	57						
L Deschutes MS-5	E	12	E	64						
Wapinitia Cr-1	E	19	E	58						
Warm Springs MS-1	E	19	E	59						
Cottonwood Cr-2	E	19	E	60						
L Deschutes MS-20	E	6	E	73						
Eagle Cr	E	19	E	62						
Robin Cr	E	7	E	74						
Booten Cr	E	3	E	80						
Hauser Canyon	E	19	E	66						
L Deschutes MS-3	E	15	E	70						
Trail Hollow Cr	E	5	E	80						
Buck Hollow Cr-5	E	13	E	74						
Finnegan Canyon	E	19	E	68						
Skookum Cr	E	19	E	69						
L Deschutes MS-2	E	9	E	80						
Trout Cr-16	E	19	E	70						
Tub Springs Canyon	E	11	E	80						
Ochoco Gulch Cr	E	13	E	80						
Hay Cr-2	E	17	E	77						
Macken Canyon	E	19	E	76						
Mud Springs Cr-4	E	16	E	79						
Mud Springs Cr-3	E	19	E	78						
White R MS-1	E	17	E	80						
Antelope Cr-3	E	19	E	80						
Fall Canyon	E	19	E	80						
Ferry Canyon	E	19	E	80						
Hay Cr-3	E	19	E	80						
Jones Canyon	E	19	E	80						
L Deschutes MS-1	E	19	E	80						
L Deschutes MS-10	E	19	E	80						
L Deschutes MS-11	E	19	E	80						
L Deschutes MS-12	E	19	E	80						
L Deschutes MS-13	E	19	E	80						
L Deschutes MS-14	E	19	E	80						
L Deschutes MS-15	E	19	E	80						
L Deschutes MS-16	E	19	E	80						
L Deschutes MS-9	E	19	E	80						
Macks Canyon	E	19	E	80						
Mud Springs Cr-5	E	19	E	80						
Mud Springs Cr-6	E	19	E	80						
Oak Canyon	E	19	E	80						
Sagebrush Cr	E	19	E	80						
Stag Canyon	E	19	E	80						
					-15% 0% 15%		-15% 0% 15%		-15% 0% 15%	
					Percentage change		Percentage change		Percentage change	

Scenario Profile Report – Change in Habitat Factors Summary

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Eastside Summer Steelhead

Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
L Deschutes MS-1																		
L Deschutes MS-2																		
Fall Canyon																		
L Deschutes MS-3									○									
L Deschutes MS-4									○									
Macks Canyon																		
L Deschutes MS-5									◯									
Ferry Canyon																		
L Deschutes MS-6									◯									
Jones Canyon																		
L Deschutes MS-7									◯									
Oak Canyon																		
L Deschutes MS-8									◯									
Buck Hollow Cr-1		◯	○				◯		◯						◯	◯		●
Finnegan Canyon							◯		○									○
Buck Hollow Cr-2		◯	○				◯		◯						◯	◯		○
Hauser Canyon							○		○									●
Buck Hollow Cr-3		◯	○				◯		◯							◯		◯
Macken Canyon									○									●
Buck Hollow Cr-4		◯	○				◯		○							◯		◯
Thorn Hollow		◯					◯		○							◯		○
Buck Hollow Cr-5							○		○									◯
L Deschutes MS-9																		
L Deschutes MS-10																		
L Deschutes MS-11																		
White R MS-1																		
L Deschutes MS-12																		
Bakeoven Cr-1		◯	○				◯		○							◯		●
Trail Hollow Cr									○									◯
Bakeoven Cr-2		◯	○				◯		◯							◯		◯
Booten Cr							◯		◯							○		◯
Bakeoven Cr-3		◯	○				◯		◯							◯		○
Robin Cr									○									◯
Bakeoven Cr-4		◯	○				◯		◯							◯		○
Deep Cr-1 (Bakeoven)		○					○		○							◯		●
Cottonwood Cr-1		○	○				○		○							◯		◯
Ochoco Gulch Cr									○							○		◯
Cottonwood Cr-2			○				○		○							◯		◯
Deep Cr-2 (Bakeoven)		◯					○		○							◯		●
Maupin Trail Canyon							○		○							◯		●
Deep Cr-3 (Bakeoven)		○					○		○							◯		○
Bakeoven Cr-5			○				○		○							○		◯
L Deschutes MS-13																		
Stag Canyon																		
L Deschutes MS-14																		
Wapinitia Cr-1									○									○
L Deschutes MS-15																		
Nena Cr-1									○									○
L Deschutes MS-16																		
Eagle Cr									○									◯
L Deschutes MS-17		◯	○						◯									
Skookum Cr									○									○
L Deschutes MS-18		◯	○						◯									
Warm Springs MS-1									○									
L Deschutes MS-19		◯							◯									
Trout Cr-1		○					○		○							◯		●

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)

A	B	C	D & E
◯ High	○ Medium	○ Low	Indirect or General
●	●	●	

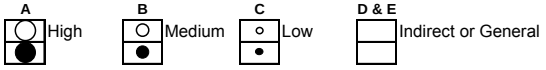
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Deschutes Eastside Summer Steelhead - continued
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Tenmile Cr		○	○				○		○							◯		●
Trout Cr-2		○	○				○		○							◯		○
Mud Springs Cr-1			○						○						○	◯		●
Mud Springs Cr-2	●										◯							
Mud Springs Cr-3			○				○		○						○	◯		●
Sagebrush Cr									○									●
Mud Springs Cr-4			○						○						○	◯		●
Mud Springs Cr-5																		
Mud Springs Cr-6			○						○						○	◯		●
Trout Cr-3		◯	○				○		○				○	○	○	◯		○
Hay Cr-1			○				○		○	○			○		●	◯		◯
Hay Cr-2											◯							
Hay Cr-3			○				◯		○	○			○	○		◯		◯
Trout Cr-4		○	○				◯		○				○	○		◯		◯
Antelope Cr-1		○	○				○		○				○	○		◯		●
Ward Cr-1		○					○		○							◯		●
Antelope Cr-2		○	○				○		○				○	○		◯		●
Antelope Cr-3																		
Antelope Cr-4		○	○				○		○				○	○	○	◯		◯
Trout Cr-5		○					○									◯		○
Tub Springs Canyon							○		○							○		●
Trout Cr-6		○					○		○				○			◯		○
Little Trout Cr		○	○				○		○							◯		●
Trout Cr-7		◯	○				◯		○				○	○	○	◯		◯
Big Whetstone Cr			○				○		○							◯		●
Trout Cr-8		◯	○				◯		○				○	○	○	◯		◯
Clover Cr			○				○		○							◯		●
Trout Cr-9		○	○				○		○				○			◯		○
Beaver Cr (Trout)			○				○		○							◯		●
Trout Cr-10			○				○		○				○		○	◯		○
Amity Cr			○				○		○				○			◯		●
Trout Cr-11		○	○				○		○						○	◯		●
Board Hollow Cr			○				○		○							○		●
Trout Cr-12		○	○				○		○							◯		●
Foley Cr-1		○	○				○		○							○		●
Big Log Cr-1			○				○									○		●
Dutchman Cr		○	○				○		○							○		●
Big Log Cr-2			○				○		○							◯		●
Foley Cr-2		○	○				○		○							○		●
Trout Cr-13		○	○				○									◯		●
Cartwright Cr			○				○		○							○		●
Trout Cr-14		○	○				○		○									●
Opal Cr-1			○				○		○				○			◯		●
Auger Cr							○		○							◯		●
Opal Cr-2		○	○				○		○				○			◯		●
Trout Cr-15			○				○		○							○		○
Potlid Cr							○		○									●
Trout Cr-16									○									●
L Deschutes MS-20									○									

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



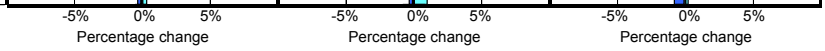
Scenario Diagnostic Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Eastside Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Buck Hollow Cr-1	A	2	A	5						
L Deschutes MS-16	A	6	A	3						
Trout Cr-3	A	9	A	6						
Trout Cr-5	A	7	A	12						
Buck Hollow Cr-3	A	3	B	17						
L Deschutes MS-18	A	3	B	20						
Trout Cr-6	B	19	A	6						
Deep Cr-2 (Bakeoven)	B	26	A	2						
L Deschutes MS-6	B	27	A	1						
Bakeoven Cr-4	B	11	B	23						
Buck Hollow Cr-2	B	13	B	21						
Trout Cr-7	A	5	B	29						
Thorn Hollow	B	31	A	4						
Antelope Cr-4	B	22	B	15						
L Deschutes MS-15	B	15	B	22						
L Deschutes MS-8	B	34	A	6						
Buck Hollow Cr-4	B	12	C	31						
Trout Cr-4	B	19	B	24						
L Deschutes MS-17	A	1	C	44						
Trout Cr-12	A	10	C	35						
Bakeoven Cr-3	B	16	C	30						
Deep Cr-1 (Bakeoven)	B	38	A	10						
L Deschutes MS-12	B	35	B	13						
Little Trout Cr	B	24	B	24						
Ward Cr-1	B	22	B	28						
Trout Cr-8	B	14	C	38						
Tenmile Cr	B	42	B	18						
Antelope Cr-2	B	21	C	43						
Cottonwood Cr-1	C	53	A	11						
Bakeoven Cr-2	B	32	C	33						
L Deschutes MS-2	B	28	C	37						
Trout Cr-14	B	18	C	49						
Deep Cr-3 (Bakeoven)	C	44	B	26						
Foley Cr-2	B	30	C	42						
L Deschutes MS-4	B	33	C	39						
Trout Cr-9	B	40	C	32						
Amity Cr	C	64	A	9						
Bakeoven Cr-1	B	17	D	56						
L Deschutes MS-13	C	55	B	18						
Antelope Cr-1	B	25	C	49						
L Deschutes MS-14	C	65	B	13						
L Deschutes MS-19	A	7	D	72						
Clover Cr	C	44	C	39						
Trout Cr-11	B	36	C	47						
Trout Cr-13	B	28	D	58						
L Deschutes MS-5	D	72	B	16						
L Deschutes MS-7	C	62	B	27						
Trout Cr-1	B	36	D	57						
Trout Cr-2	C	48	C	45						
Dutchman Cr	B	38	D	58						
Trout Cr-10	C	63	C	34						



Continued next page

Deschutes Eastside Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Potlid Cr	B	41	D	58						
Maupin Trail Canyon	C	65	C	35						
Opal Cr-2	C	47	D	53						
Board Hollow Cr	B	42	D	64						
Nena Cr-1	C	60	C	46						
Mud Springs Cr-4	C	59	C	51						
Beaver Cr (Trout)	C	50	D	61						
Big Whetstone Cr	C	57	D	54						
Cartwright Cr	C	49	D	63						
Mud Springs Cr-1	C	57	D	55						
Mud Springs Cr-6	C	68	C	48						
Trout Cr-15	C	51	D	67						
Cottonwood Cr-2	D	81	C	39						
Big Log Cr-2	C	54	D	67						
Hay Cr-3	D	75	C	51						
Auger Cr	C	51	D	76						
Foley Cr-1	C	46	D	81						
Opal Cr-1	C	56	D	74						
L Deschutes MS-11	C	69	D	66						
Hay Cr-1	C	70	D	67						
Warm Springs MS-1	C	60	E	82						
L Deschutes MS-9	D	78	D	65						
Wapinitia Cr-1	D	73	D	71						
L Deschutes MS-3	C	67	D	79						
Eagle Cr	D	81	D	67						
Mud Springs Cr-3	D	87	D	62						
L Deschutes MS-20	D	74	D	77						
L Deschutes MS-1	D	78	D	79						
Skookum Cr	D	76	E	85						
Stag Canyon	D	84	D	77						
Bakeoven Cr-5	D	78	E	84						
Big Log Cr-1	D	71	E	92						
Finnegan Canyon	D	77	E	86						
Ferry Canyon	E	95	D	73						
Oak Canyon	E	93	D	75						
Hauser Canyon	D	84	E	89						
Buck Hollow Cr-5	D	86	E	89						
Macks Canyon	E	92	E	83						
Booten Cr	D	88	E	88						
Macken Canyon	D	91	E	86						
Tub Springs Canyon	D	83	E	97						
Robin Cr	D	89	E	94						
Sagebrush Cr	E	94	E	92						
Trail Hollow Cr	E	95	E	91						
Trout Cr-16	D	90	E	99						
Jones Canyon	E	97	E	95						
Fall Canyon	E	97	E	96						
Ochoco Gulch Cr	E	97	E	98						
Antelope Cr-3	E	97	E	100						
Hay Cr-2	E	97	E	100						
L Deschutes MS-10	E	97	E	100						
Mud Springs Cr-2	E	97	E	100						
Mud Springs Cr-5	E	97	E	100						
White R MS-1	E	97	E	100						
					-5% 0% 5%		-5% 0% 5%		-5% 0% 5%	
					Percentage change		Percentage change		Percentage change	

Scenario Diagnostic Report – Diagnostic Summary

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Eastside Summer Steelhead

Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
L Deschutes MS-1					●				●					●				●
L Deschutes MS-2	○	∘			●				●					●				●
Fall Canyon							●		●									●
L Deschutes MS-3	∘				●				●					●				
L Deschutes MS-4	○	∘			●				●					●				
Macks Canyon			●				●		●									●
L Deschutes MS-5		○			●				●					●	●			
Ferry Canyon							●		●						●			●
L Deschutes MS-6	○	◯			●				●					●	●			
Jones Canyon			●				●		●									●
L Deschutes MS-7	∘	○			●				●					●	●			
Oak Canyon			●				●		●									●
L Deschutes MS-8	○	◯			●				●					●	●			
Buck Hollow Cr-1	◯	◯					●							●	●	●		●
Finnegan Canyon							●		●									●
Buck Hollow Cr-2	○	○					●							●	●	●		●
Hauser Canyon							●		●									
Buck Hollow Cr-3	◯	○					●							●		●		●
Macken Canyon							●		●									
Buck Hollow Cr-4	○	∘					●							●		●		●
Thorn Hollow	○	◯					●		●					●		●		●
Buck Hollow Cr-5														●				●
L Deschutes MS-9					●		●		●									●
L Deschutes MS-10																		
L Deschutes MS-11	∘				●				●					●				●
White R MS-1									●					●				●
L Deschutes MS-12	○	○	●		●		●		●					●				
Bakeoven Cr-1	○						●							●		●		●
Trail Hollow Cr							●		●									●
Bakeoven Cr-2	○	∘					●							●		●		●
Booten Cr			●				●		●							●		●
Bakeoven Cr-3	○	∘					●							●		●		●
Robin Cr							●		●									●
Bakeoven Cr-4	○	○					●		●					●		●		●
Deep Cr-1 (Bakeoven)	○	◯					●		●					●		●		●
Cottonwood Cr-1	∘	◯					●		●					●		●		●
Ochoco Gulch Cr							●		●							●		●
Cottonwood Cr-2		∘					●		●					●		●		●
Deep Cr-2 (Bakeoven)	○	◯					●		●					●		●		●
Maupin Trail Canyon	∘	∘					●		●					●		●		●
Deep Cr-3 (Bakeoven)	∘	○					●		●					●		●		●
Bakeoven Cr-5									●					●				●
L Deschutes MS-13	∘	○	●		●		●		●	●			●	●		●		
Stag Canyon			●				●		●				●	●		●		
L Deschutes MS-14	∘	○	●		●		●		●					●				●
Wapinitia Cr-1							●		●					●				●
L Deschutes MS-15	○	○			●		●		●					●				
Nena Cr-1	∘	∘					●		●					●				●
L Deschutes MS-16	◯	◯					●		●									
Eagle Cr							●		●					●				●
L Deschutes MS-17	◯	∘			●				●					●				●
Skookum Cr							●		●									●
L Deschutes MS-18	◯	○			●				●					●				
Warm Springs MS-1	∘				●				●				●					
L Deschutes MS-19	◯				●				●					●				
Trout Cr-1	○						●		●					●		●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
◯ ● High	○ ● Medium	∘ • Low	Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Continued next page

Deschutes Eastside Summer Steelhead - continued
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Tenmile Cr	○	○					●		●					●		●		●
Trout Cr-2	○	○					●		●					●		●		●
Mud Springs Cr-1	○		●											●	●	●		
Mud Springs Cr-2																		
Mud Springs Cr-3			●				●		●					●	●	●		●
Sagebrush Cr									●									
Mud Springs Cr-4	○	○	●						●					●	●	●		
Mud Springs Cr-5																		
Mud Springs Cr-6	○	○	●				●							●	●	●		
Trout Cr-3	◯	◯					●		●					●	●	●		●
Hay Cr-1	○						●		●					●		●		●
Hay Cr-2																		
Hay Cr-3		○					●		●					●		●		●
Trout Cr-4	○	○					●							●		●		●
Antelope Cr-1	○	○					●							●		●		●
Ward Cr-1	○	○					●		●					●		●		
Antelope Cr-2	○	○					●							●		●		●
Antelope Cr-3																		
Antelope Cr-4	○	○					●							●	●	●		●
Trout Cr-5	◯	◯					●							●		●		●
Tub Springs Canyon							●		●									●
Trout Cr-6	○	◯					●		●					●		●		●
Little Trout Cr	○	○					●							●		●		●
Trout Cr-7	◯	○					●							●		●		●
Big Whetstone Cr	○						●		●					●		●		
Trout Cr-8	○	○					●							●		●		●
Clover Cr	○	○					●		●					●		●		
Trout Cr-9	○	○					●		●					●		●		●
Beaver Cr (Trout)	○						●		●					●		●		
Trout Cr-10	○	○					●							●		●		●
Amity Cr	○	◯					●		●				●	●		●		●
Trout Cr-11	○	○					●		●					●		●		
Board Hollow Cr	○						●		●					●		●		●
Trout Cr-12	◯	○					●		●					●		●		●
Foley Cr-1	○		●				●		●					●		●		●
Big Log Cr-1							●		●					●		●		
Dutchman Cr	○						●		●					●		●		
Big Log Cr-2	○						●		●					●		●		●
Foley Cr-2	○	○					●							●		●		●
Trout Cr-13	○						●							●		●		
Cartwright Cr	○						●		●					●		●		
Trout Cr-14	○	○					●		●					●				
Opal Cr-1	○		●				●		●					●		●		
Auger Cr	○						●		●					●		●		
Opal Cr-2	○		●				●		●					●		●		
Trout Cr-15	○						●		●					●				●
Potlid Cr	○						●		●					●				●
Trout Cr-16							●		●									●
L Deschutes MS-20									●					●				

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

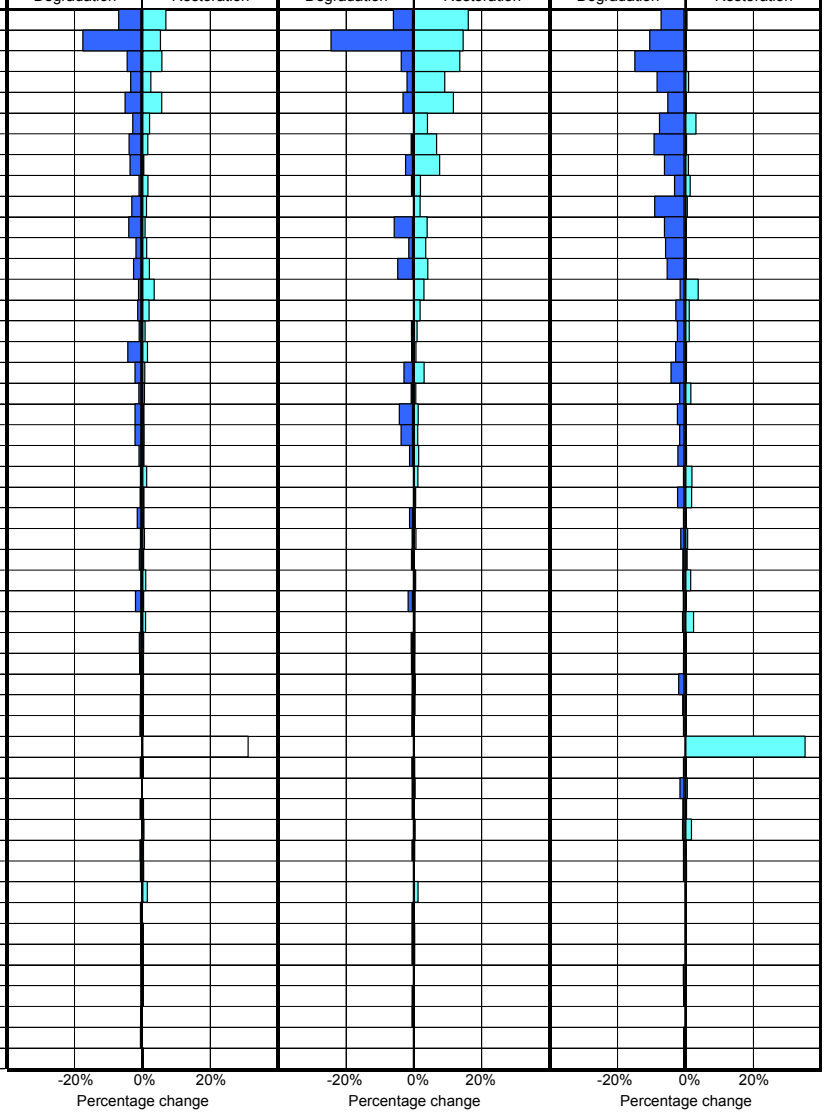
A	B	C	D & E
◯ High	○ Medium	○ Low	Indirect or General
●	●	●	

Baseline Diagnostic Report – Tornado Chart

Deschutes Westside Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit	
	Category	rank	Category	rank
Beaver Cr-1 (WS)	A	2	B	3
Shitike Cr-3	A	1	B	6
Boulder Cr (WS)	A	3	B	5
Warm Springs MS-7	B	6	B	4
Shitike Cr-2	B	5	B	7
L Deschutes MS-20	C	16	A	1
Warm Springs MS-9	B	8	B	10
Shitike Cr-1	B	7	B	13
Warm Springs MS-3	D	18	B	7
Badger Cr (WS)	C	15	B	12
Beaver Cr-2 (WS)	B	4	C	23
Mill Cr-2 (WS)	C	12	C	16
Beaver Cr-3 (WS)	B	8	C	21
Wapinitia Cr-1	D	27	A	2
L Deschutes MS-21	D	23	B	9
Warm Springs MS-1	D	19	B	14
Warm Springs MS-5	C	14	C	22
Warm Springs MS-8	B	11	C	26
L Deschutes MS-17	D	20	C	18
Beaver Cr-4 (WS)	B	10	D	30
Beaver Cr-5 (WS)	C	13	D	30
Warm Springs MS-6	C	16	C	27
Nena Cr-1	E	37	B	11
L Deschutes MS-18	D	29	C	20
L Deschutes MS-4	D	22	D	32
Warm Springs MS-4	D	32	C	23
L Deschutes MS-16	D	24	D	32
Eagle Cr	E	41	C	16
L Deschutes MS-2	D	20	D	38
Wapinitia Cr-2	E	40	C	18
L Deschutes MS-6	D	26	D	34
L Deschutes MS-8	D	25	D	37
Mill Cr-1 (WS)	D	35	D	29
Trout Cr-1	D	33	D	36
L Deschutes MS-11	D	28	D	42
Pelton Dam complex	E	56	B	14
L Deschutes MS-12	D	30	D	41
L Deschutes MS-19	D	36	D	35
L Deschutes MS-15	D	34	D	38
Skookum Cr	E	44	C	28
Bunchgrass Cr	D	30	D	43
L Deschutes MS-14	E	38	D	40
Warm Springs MS-2	E	56	C	25
L Deschutes MS-5	E	39	E	48
L Deschutes MS-1	E	43	E	45
L Deschutes MS-3	E	42	E	46
Stag Canyon	E	44	E	47
L Deschutes MS-13	E	49	D	43
L Deschutes MS-7	E	44	E	50
Buck Hollow Cr-1	E	44	E	54
Trout Cr-2	E	52	E	48



Continued next page

Deschutes Westside Summer Steelhead - continued

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with				Change in Productivity with				Change in Diversity Index with			
	Category/rank		Category/rank		Degradation		Restoration		Degradation		Restoration		Degradation		Restoration	
L Deschutes MS-9	E	50	E	52												
Bakeoven Cr-1	E	48	E	56												
Oak Canyon	E	53	E	52												
White R MS-1	E	54	E	51												
Paquet Gulch-1	E	51	E	57												
Jones Canyon	E	55	E	55												
Abbot Cr	E	56	E	58												
Candle Cr	E	56	E	58												
Canyon Cr-1 (Met)	E	56	E	58												
Crooked MS-1	E	56	E	58												
Ferry Canyon	E	56	E	58												
First Cr	E	56	E	58												
Fly Cr-1	E	56	E	58												
Indian Ford Cr	E	56	E	58												
Jack Cr-1	E	56	E	58												
Jack Cr-2	E	56	E	58												
Jefferson Cr	E	56	E	58												
L Deschutes MS-10	E	56	E	58												
Lake Cr MF-1	E	56	E	58												
Lake Cr MF-2	E	56	E	58												
Lake Cr SF	E	56	E	58												
Lake Cr-1	E	56	E	58												
M Deschutes MS-10	E	56	E	58												
M Deschutes MS-4	E	56	E	58												
M Deschutes MS-5	E	56	E	58												
M Deschutes MS-6	E	56	E	58												
M Deschutes MS-7	E	56	E	58												
M Deschutes MS-8	E	56	E	58												
M Deschutes MS-9	E	56	E	58												
Macks Canyon	E	56	E	58												
Metolius MS-1	E	56	E	58												
Metolius MS-10	E	56	E	58												
Metolius MS-11	E	56	E	58												
Metolius MS-12	E	56	E	58												
Metolius MS-13	E	56	E	58												
Metolius MS-14	E	56	E	58												
Metolius MS-2	E	56	E	58												
Metolius MS-3	E	56	E	58												
Metolius MS-4	E	56	E	58												
Metolius MS-5	E	56	E	58												
Metolius MS-6	E	56	E	58												
Metolius MS-7	E	56	E	58												
Metolius MS-8	E	56	E	58												
Metolius MS-9	E	56	E	58												
Snow Cr (Squaw)	E	56	E	58												
Spring Cr-1	E	56	E	58												
Spring Cr-1 (Met)	E	56	E	58												
Squaw Cr-1	E	56	E	58												
Squaw Cr-2	E	56	E	58												
Squaw Cr-3	E	56	E	58												
Squaw Cr-4	E	56	E	58												
Squaw Cr-5	E	56	E	58												
Squaw Cr-6	E	56	E	58												
Squaw Cr-7	E	56	E	58												
Squaw Cr-8	E	56	E	58												
Street Cr-1	E	56	E	58												
Street Cr-2	E	56	E	58												
Whitewater R	E	56	E	58												
					-20% 0% 20%				-20% 0% 20%				-20% 0% 20%			
					Percentage change				Percentage change				Percentage change			

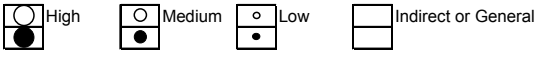
Baseline Diagnostic Report – Diagnostic Summary

Deschutes Westside Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
L Deschutes MS-1									●					●				
L Deschutes MS-2					●				⬤					●				⬤
L Deschutes MS-3									●					●				
L Deschutes MS-4					●				⬤					●				
Macks Canyon							●		●									⬤
L Deschutes MS-5					●				⬤					●				
Ferry Canyon							●		●						●			⬤
L Deschutes MS-6					●				⬤					●				
Jones Canyon			●				●		⬤									⬤
L Deschutes MS-7					●				⬤					●				
Oak Canyon			●				●		●									⬤
L Deschutes MS-8					●				⬤					●				
Buck Hollow Cr-1			●				●		●					●				●
L Deschutes MS-9					●		●		●									●
L Deschutes MS-10																		
L Deschutes MS-11					●		●		●					●				●
White R MS-1					●		⬤		●					●		●		●
L Deschutes MS-12					●				⬤					●				
Bakeoven Cr-1							●		●					●				●
L Deschutes MS-13					●		●		⬤				●	●				
Stag Canyon			●				●		⬤					●		●		
L Deschutes MS-14			●		●		●		⬤					●				●
Wapinitia Cr-1		◯	●				⬤		⬤					⬤	⬤	⬤		⬤
Paquet Gulch-1							⬤		●							⬤		⬤
Wapinitia Cr-2		○	●				⬤		●				●	●	●	⬤		⬤
L Deschutes MS-15					●				⬤									
Nena Cr-1		○	●				⬤		⬤				●	⬤		⬤		⬤
L Deschutes MS-16							●		⬤									
Eagle Cr		○	●				⬤		⬤				●	⬤		⬤		⬤
L Deschutes MS-17		○			●		●		⬤					●				
Skookum Cr		○	●				⬤		⬤				●	●		⬤		⬤
L Deschutes MS-18		○			●				⬤									
Warm Springs MS-1		◯			●		●		⬤									
Warm Springs MS-2		○									●							
Warm Springs MS-3		◯			●		●		●				●	●				
Beaver Cr-1 (WS)	◯	◯	●		●		●		●					●	⬤	●		⬤
Beaver Cr-2 (WS)	○	○					●		●							●		
Beaver Cr-3 (WS)	○	○					●		●						●	●		⬤
Beaver Cr-4 (WS)	○						●									●		⬤
Beaver Cr-5 (WS)	○						●									●		●
Warm Springs MS-4		○			●		●		⬤									●
Mill Cr-1 (WS)					●		●		●									●
Boulder Cr (WS)	◯	○	●				⬤		●							●		●
Mill Cr-2 (WS)	○	○	●		●		⬤		●					●	⬤			●
Warm Springs MS-5	○	○							●									
Badger Cr (WS)	○	◯					⬤		●							●		●
Warm Springs MS-6	○	○					●		●						⬤			●
Warm Springs MS-7	○	◯					●		⬤						⬤			
Warm Springs MS-8	○	○					●		●						⬤			
Bunchgrass Cr									●									●
Warm Springs MS-9	○	◯					●		●						⬤			
L Deschutes MS-19					●				⬤									
Trout Cr-1							●		⬤							●		●
Trout Cr-2							●		⬤					●		●		⬤
L Deschutes MS-20	○	◯			●		●		⬤					●				
Shitike Cr-1	◯	◯	●		●		●	●	⬤						⬤	●		⬤

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Continued next page

Deschutes Westside Summer Steelhead - continued
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Shitike Cr-2	○	○	•		•		•	•	●							•		•
Shitike Cr-3	◯	○			•											•		•
L Deschutes MS-21		○			•		•		●					•				•
Pelton Dam complex		○									●							
M Deschutes MS-4					•				●					•	●	•		●
Metolius MS-1									●					•	●	•		●
Fly Cr-1									●					•	●	•		●
Metolius MS-2					•				●					•	●	•		●
Spring Cr-1									●					●	●	•		●
Metolius MS-3					•				●					•	●	•		●
Street Cr-1									●					•	●	•		●
Street Cr-2							•		•						•			•
Metolius MS-4					•				●					•	●	•		●
Metolius MS-5					•									•				
Whitewater R																		
Metolius MS-6					•									•				
Jefferson Cr									•									
Metolius MS-7														•				●
Candle Cr									•									
Metolius MS-8					•				•					•				
Abbot Cr									•						●			
Metolius MS-9					●				•					•				•
Canyon Cr-1 (Met)									•									
Metolius MS-10					•				•					•				
Jack Cr-1									●									●
Jack Cr-2																		
Metolius MS-11					●				●					•				●
First Cr							•											•
Metolius MS-12					•			•	•					•				
Spring Cr-1 (Met)									●									
Metolius MS-13					•				•					•				•
Lake Cr MF-1			•		•				•					•	•	•		
Lake Cr SF					•									•		•		
Lake Cr MF-2					•				•					•		•		
Lake Cr-1					•				•					•		•		
Metolius MS-14					•				•					•				
M Deschutes MS-5					•				●				•	•		•		•
Crooked MS-1									●					•	●	•		●
M Deschutes MS-6					•				●					•	●	•		●
M Deschutes MS-7					•				•									
Squaw Cr-1									•									●
Squaw Cr-2			●				•		•				•	●	•	●		●
Indian Ford Cr			•				•		•						●	●		●
Squaw Cr-3			●				●	•	●				•	●	●	●		●
Squaw Cr-4											●							
Squaw Cr-5			•				•		•					●	●	•		●
Squaw Cr-6											●							
Squaw Cr-7			•						•					•				●
Snow Cr (Squaw)																		
Squaw Cr-8																		•
M Deschutes MS-8					•		•		•					•				•
M Deschutes MS-9																		
M Deschutes MS-10					•		•		•					•				●

Key to strategic priority (corresponding Benefit Category letter also shown)

A ◯/● High B ○/● Medium C ○/• Low D & E Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Westside Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Pelton Dam complex	B	1	A	8						
Warm Springs MS-7	E	15	A	1						
Shitike Cr-1	E	15	A	2						
Beaver Cr-1 (WS)	E	15	A	3						
L Deschutes MS-20	E	15	A	4						
Boulder Cr (WS)	E	15	A	5						
Warm Springs MS-3	E	15	A	6						
Warm Springs MS-9	E	15	A	7						
Wapinitia Cr-1	E	2	C	21						
Shitike Cr-2	E	15	A	9						
L Deschutes MS-21	E	15	A	10						
Shitike Cr-3	E	15	A	11						
Beaver Cr-3 (WS)	E	15	B	12						
Warm Springs MS-1	E	15	B	12						
Nena Cr-1	E	4	E	24						
L Deschutes MS-17	E	15	B	14						
L Deschutes MS-18	E	15	B	14						
Mill Cr-2 (WS)	E	15	B	14						
Wapinitia Cr-2	E	5	E	25						
Badger Cr (WS)	E	9	C	23						
Eagle Cr	E	6	E	26						
Warm Springs MS-8	E	15	B	17						
Warm Springs MS-5	E	15	B	18						
Beaver Cr-2 (WS)	E	15	B	19						
Warm Springs MS-6	E	15	C	20						
Warm Springs MS-4	E	15	C	21						
Skookum Cr	E	7	E	32						
Buck Hollow Cr-1	E	9	E	33						
Mill Cr-1 (WS)	E	15	E	27						
L Deschutes MS-19	E	15	E	28						
Trout Cr-1	E	15	E	29						
Beaver Cr-4 (WS)	E	11	E	34						
Beaver Cr-5 (WS)	E	2	E	43						
L Deschutes MS-4	E	15	E	30						
Bunchgrass Cr	E	15	E	31						
L Deschutes MS-6	E	15	E	34						
Bakeoven Cr-1	E	11	E	39						
White R MS-1	E	7	E	43						
Trout Cr-2	E	15	E	36						
L Deschutes MS-3	E	15	E	37						
L Deschutes MS-8	E	15	E	38						
L Deschutes MS-5	E	15	E	40						
Paquet Gulch-1	E	13	E	42						
L Deschutes MS-2	E	13	E	43						
L Deschutes MS-7	E	15	E	41						
Abbot Cr	E	15	E	43						
Candle Cr	E	15	E	43						
Canyon Cr-1 (Met)	E	15	E	43						
Crooked MS-1	E	15	E	43						
Ferry Canyon	E	15	E	43						
First Cr	E	15	E	43						
					-20% 0% 20%		-20% 0% 20%		-20% 0% 20%	
					Percentage change		Percentage change		Percentage change	

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Deschutes Westside Summer Steelhead - continued

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance				Change in Productivity with				Change in Diversity Index with			
	Category/rank		Category/rank		Loss		Gain		Loss		Gain		Loss		Gain	
Fly Cr-1	E	15	E	43												
Indian Ford Cr	E	15	E	43												
Jack Cr-1	E	15	E	43												
Jack Cr-2	E	15	E	43												
Jefferson Cr	E	15	E	43												
Jones Canyon	E	15	E	43												
L Deschutes MS-1	E	15	E	43												
L Deschutes MS-10	E	15	E	43												
L Deschutes MS-11	E	15	E	43												
L Deschutes MS-12	E	15	E	43												
L Deschutes MS-13	E	15	E	43												
L Deschutes MS-14	E	15	E	43												
L Deschutes MS-15	E	15	E	43												
L Deschutes MS-16	E	15	E	43												
L Deschutes MS-9	E	15	E	43												
Lake Cr MF-1	E	15	E	43												
Lake Cr MF-2	E	15	E	43												
Lake Cr SF	E	15	E	43												
Lake Cr-1	E	15	E	43												
M Deschutes MS-10	E	15	E	43												
M Deschutes MS-4	E	15	E	43												
M Deschutes MS-5	E	15	E	43												
M Deschutes MS-6	E	15	E	43												
M Deschutes MS-7	E	15	E	43												
M Deschutes MS-8	E	15	E	43												
M Deschutes MS-9	E	15	E	43												
Macks Canyon	E	15	E	43												
Metolius MS-1	E	15	E	43												
Metolius MS-10	E	15	E	43												
Metolius MS-11	E	15	E	43												
Metolius MS-12	E	15	E	43												
Metolius MS-13	E	15	E	43												
Metolius MS-14	E	15	E	43												
Metolius MS-2	E	15	E	43												
Metolius MS-3	E	15	E	43												
Metolius MS-4	E	15	E	43												
Metolius MS-5	E	15	E	43												
Metolius MS-6	E	15	E	43												
Metolius MS-7	E	15	E	43												
Metolius MS-8	E	15	E	43												
Metolius MS-9	E	15	E	43												
Oak Canyon	E	15	E	43												
Snow Cr (Squaw)	E	15	E	43												
Spring Cr-1	E	15	E	43												
Spring Cr-1 (Met)	E	15	E	43												
Squaw Cr-1	E	15	E	43												
Squaw Cr-2	E	15	E	43												
Squaw Cr-3	E	15	E	43												
Squaw Cr-4	E	15	E	43												
Squaw Cr-5	E	15	E	43												
Squaw Cr-6	E	15	E	43												
Squaw Cr-7	E	15	E	43												
Squaw Cr-8	E	15	E	43												
Stag Canyon	E	15	E	43												
Street Cr-1	E	15	E	43												
Street Cr-2	E	15	E	43												
Warm Springs MS-2	E	15	E	43												
Whitewater R	E	15	E	43												
					-20%	0%	20%		-20%	0%	20%		-20%	0%	20%	
					Percentage change				Percentage change				Percentage change			

Scenario Profile Report – Change in Habitat Factors Summary

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Westside Summer Steelhead

Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario																
Geographic area	Relative loss	Relative gain	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
L Deschutes MS-1																		
L Deschutes MS-2																		
L Deschutes MS-3																		
L Deschutes MS-4									○									
Macks Canyon																		
L Deschutes MS-5									○									
Ferry Canyon																		
L Deschutes MS-6									◯									
Jones Canyon																		
L Deschutes MS-7									◯									
Oak Canyon																		
L Deschutes MS-8									◯									
Buck Hollow Cr-1			○				○		○									•
L Deschutes MS-9																		
L Deschutes MS-10																		
L Deschutes MS-11																		
White R MS-1							◯											•
L Deschutes MS-12																		
Bakeoven Cr-1									○									•
L Deschutes MS-13																		
Stag Canyon																		
L Deschutes MS-14																		
Wapinitia Cr-1		○					○		○						○	○		○
Paquet Gulch-1							○									○		○
Wapinitia Cr-2							○		○							◯		○
L Deschutes MS-15																		
Nena Cr-1			○				○		○							◯		○
L Deschutes MS-16																		
Eagle Cr			○				○		○							◯		○
L Deschutes MS-17		○							◯									
Skookum Cr							○		○							◯		○
L Deschutes MS-18		○							◯									
Warm Springs MS-1		○							○									
Warm Springs MS-2																		
Warm Springs MS-3		◯					○		○									
Beaver Cr-1 (WS)		◯	○				○								◯	○		○
Beaver Cr-2 (WS)		○					○		○							○		•
Beaver Cr-3 (WS)		○					○											○
Beaver Cr-4 (WS)							○									○		●
Beaver Cr-5 (WS)							○											●
Warm Springs MS-4		○							○									•
Mill Cr-1 (WS)							○											○
Boulder Cr (WS)		◯	○				◯		○							○		●
Mill Cr-2 (WS)		○	○				○		○						◯			○
Warm Springs MS-5		○							○									
Badger Cr (WS)		○					○		○									●
Warm Springs MS-6		○							○						◯			
Warm Springs MS-7		◯							○						◯			
Warm Springs MS-8		○							○						◯			
Bunchgrass Cr									○									
Warm Springs MS-9		◯					○		○						◯			•
L Deschutes MS-19									◯									
Trout Cr-1									○							○		•
Trout Cr-2							○		◯							○		○
L Deschutes MS-20		◯							◯									
Shitike Cr-1		◯	○				○		○						◯	○		•

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)

A	B	C	D & E
◯ High	○ Medium	○ Low	Indirect or General
●	●	•	

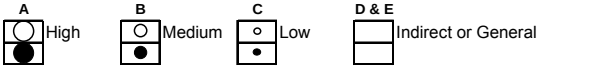
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Deschutes Westside Summer Steelhead - continued
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Shitike Cr-2		◯					o		o							o		●
Shitike Cr-3		◯														o		●
L Deschutes MS-21		◯							◯									
Pelton Dam complex	●	◯									◯							
M Deschutes MS-4																		
Metolius MS-1																		
Fly Cr-1															◯			●
Metolius MS-2																		
Spring Cr-1															◯			●
Metolius MS-3																		
Street Cr-1															◯			●
Street Cr-2									o									
Metolius MS-4																		
Metolius MS-5																		
Whitewater R																		●
Metolius MS-6																		
Jefferson Cr									o									●
Metolius MS-7																		
Candle Cr									o									
Metolius MS-8									o									
Abbot Cr									o						o			o
Metolius MS-9									o									
Canyon Cr-1 (Met)									o									
Metolius MS-10																		
Jack Cr-1									◯									
Jack Cr-2																		
Metolius MS-11					o				◯									
First Cr																		o
Metolius MS-12									o									
Spring Cr-1 (Met)									◯									
Metolius MS-13																		
Lake Cr MF-1			o						o						o	o		●
Lake Cr SF																o		o
Lake Cr MF-2									o							o		●
Lake Cr-1									o							o		●
Metolius MS-14									o									
M Deschutes MS-5																		
Crooked MS-1																		
M Deschutes MS-6																		
M Deschutes MS-7																		
Squaw Cr-1									o									o
Squaw Cr-2			◯				o		o				o	o	o	◯		◯
Indian Ford Cr							o		o						◯	◯		o
Squaw Cr-3			◯				◯		◯				o	o	◯	◯		◯
Squaw Cr-4											◯							
Squaw Cr-5			o				o		o						◯	o		◯
Squaw Cr-6											◯							
Squaw Cr-7									o									◯
Snow Cr (Squaw)																		●
Squaw Cr-8																		o
M Deschutes MS-8																		●
M Deschutes MS-9																		
M Deschutes MS-10																		

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



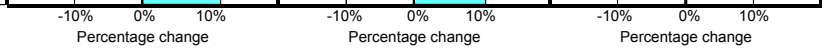
Scenario Diagnostic Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Westside Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Beaver Cr-1 (WS)	A	4	B	3						
Shitike Cr-3	A	1	B	6						
Boulder Cr (WS)	A	2	B	6						
Shitike Cr-2	B	6	B	6						
Squaw Cr-2	A	3	C	17						
Squaw Cr-7	B	8	C	12						
Warm Springs MS-7	A	5	C	15						
L Deschutes MS-20	B	12	C	10						
Warm Springs MS-9	B	10	C	16						
Warm Springs MS-3	C	22	B	5						
Beaver Cr-3 (WS)	B	11	D	19						
L Deschutes MS-21	C	29	C	9						
Beaver Cr-2 (WS)	B	8	D	31						
Mill Cr-2 (WS)	B	14	D	25						
M Deschutes MS-8	C	27	C	14						
L Deschutes MS-17	C	24	D	20						
Indian Ford Cr	B	20	D	26						
Wapinitia Cr-1	C	45	B	2						
Beaver Cr-5 (WS)	C	24	D	24						
L Deschutes MS-2	C	32	C	17						
Warm Springs MS-5	B	18	D	33						
Beaver Cr-4 (WS)	B	18	D	35						
Warm Springs MS-1	C	27	D	28						
L Deschutes MS-4	C	33	D	23						
Lake Cr MF-2	C	29	D	29						
Nena Cr-1	D	55	B	4						
Shitike Cr-1	B	6	D	54						
Warm Springs MS-4	C	40	D	20						
Badger Cr (WS)	B	15	D	47						
L Deschutes MS-18	C	36	D	26						
Warm Springs MS-8	B	13	D	51						
Squaw Cr-1	C	31	D	38						
L Deschutes MS-16	C	38	D	33						
Lake Cr SF	C	33	D	39						
Squaw Cr-3	C	22	D	52						
Warm Springs MS-6	C	26	D	48						
Eagle Cr	D	62	C	13						
Snow Cr (Squaw)	B	16	D	60						
L Deschutes MS-12	D	48	D	29						
L Deschutes MS-8	C	42	D	36						
L Deschutes MS-6	C	37	D	43						
Mill Cr-1 (WS)	C	44	D	37						
Squaw Cr-8	B	17	D	65						
Lake Cr-1	C	40	D	44						
M Deschutes MS-10	C	43	D	44						
Squaw Cr-5	C	35	D	52						
Abbot Cr	B	21	D	67						
L Deschutes MS-15	D	50	D	40						
M Deschutes MS-7	D	51	D	41						
Wapinitia Cr-2	D	60	D	32						
Pelton Dam complex	E	97	A	1						



Continued next page

Deschutes Westside Summer Steelhead - continued

Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
L Deschutes MS-19	D	49	D	50						
Skookum Cr	D	79	D	20						
Metolius MS-6	D	47	D	56						
L Deschutes MS-14	D	64	D	41						
L Deschutes MS-11	D	46	D	61						
Warm Springs MS-2	E	97	C	10						
Metolius MS-9	D	54	D	58						
Lake Cr MF-1	C	39	D	75						
L Deschutes MS-1	D	65	D	54						
L Deschutes MS-13	D	70	D	49						
Trout Cr-1	D	58	D	62						
L Deschutes MS-7	D	53	D	68						
Metolius MS-1	D	58	D	64						
Metolius MS-8	D	63	D	59						
Bunchgrass Cr	D	52	D	71						
L Deschutes MS-5	D	60	D	65						
L Deschutes MS-3	D	56	D	70						
L Deschutes MS-9	D	75	D	57						
M Deschutes MS-6	D	56	D	77						
M Deschutes MS-4	E	80	D	62						
Crooked MS-1	E	97	D	46						
Buck Hollow Cr-1	D	67	E	83						
Metolius MS-5	D	68	E	82						
Spring Cr-1 (Met)	D	74	D	77						
M Deschutes MS-5	D	77	D	75						
Metolius MS-14	D	72	E	80						
Jefferson Cr	D	65	E	89						
Stag Canyon	E	85	D	69						
Metolius MS-12	D	71	E	85						
Bakeoven Cr-1	D	68	E	89						
Metolius MS-4	E	84	D	73						
Candle Cr	D	73	E	85						
Oak Canyon	E	86	D	72						
Metolius MS-2	E	83	D	77						
Metolius MS-11	D	77	E	85						
Metolius MS-3	E	91	D	73						
Trout Cr-2	E	81	E	85						
First Cr	D	76	E	96						
Metolius MS-10	E	81	E	93						
White R MS-1	E	88	E	89						
M Deschutes MS-9	E	97	E	81						
Spring Cr-1	E	97	E	84						
Metolius MS-7	E	87	E	95						
Jones Canyon	E	94	E	92						
Metolius MS-13	E	90	E	97						
Paquet Gulch-1	E	92	E	98						
Canyon Cr-1 (Met)	E	97	E	94						
Whitewater R	E	88	E	103						
Jack Cr-1	E	94	E	99						
Jack Cr-2	E	93	E	100						
Street Cr-1	E	96	E	101						
Street Cr-2	E	97	E	102						
Ferry Canyon	E	97	E	103						
Fly Cr-1	E	97	E	103						
L Deschutes MS-10	E	97	E	103						
Macks Canyon	E	97	E	103						
Squaw Cr-4	E	97	E	103						
Squaw Cr-6	E	97	E	103						
					-10% 0% 10%		-10% 0% 10%		-10% 0% 10%	
					Percentage change		Percentage change		Percentage change	

Scenario Diagnostic Report – Diagnostic Summary

Priority 1 and 2 Subbasin Actions – 100 years

Deschutes Westside Summer Steelhead

Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
L Deschutes MS-1									●					●				
L Deschutes MS-2	○	○			●				●					●				●
L Deschutes MS-3														●				
L Deschutes MS-4	○				●				●					●				
Macks Canyon							●		●									●
L Deschutes MS-5					●				●					●				
Ferry Canyon							●		●						●			●
L Deschutes MS-6	○				●				●					●				
Jones Canyon			●				●		●									●
L Deschutes MS-7					●				●					●				
Oak Canyon			●				●		●									●
L Deschutes MS-8	○				●				●					●				
Buck Hollow Cr-1														●				●
L Deschutes MS-9					●		●		●									●
L Deschutes MS-10																		
L Deschutes MS-11					●		●		●					●				●
White R MS-1					●		●		●					●		●		●
L Deschutes MS-12					●				●					●				
Bakeoven Cr-1														●				●
L Deschutes MS-13					●		●		●				●	●				
Stag Canyon			●				●		●					●		●		
L Deschutes MS-14			●		●		●		●					●				●
Wapinitia Cr-1	○	○					●		●					●	●	●		●
Paquet Gulch-1							●		●							●		●
Wapinitia Cr-2							●		●					●		●		●
L Deschutes MS-15					●				●									
Nena Cr-1		○	●				●		●					●		●		●
L Deschutes MS-16	○						●		●									
Eagle Cr		○	●				●		●					●		●		●
L Deschutes MS-17	○				●				●					●				●
Skookum Cr							●		●					●		●		●
L Deschutes MS-18	○				●				●									
Warm Springs MS-1	○				●				●									
Warm Springs MS-2		○									●							
Warm Springs MS-3	○	○			●		●		●					●				
Beaver Cr-1 (WS)	◯	○			●		●								●			●
Beaver Cr-2 (WS)	○																	
Beaver Cr-3 (WS)	○						●											●
Beaver Cr-4 (WS)	○						●											●
Beaver Cr-5 (WS)	○						●											●
Warm Springs MS-4	○				●				●									●
Mill Cr-1 (WS)	○				●		●											
Boulder Cr (WS)	◯	○					●											●
Mill Cr-2 (WS)	○				●		●							●				●
Warm Springs MS-5	○																	
Badger Cr (WS)	○						●											●
Warm Springs MS-6	○														●			●
Warm Springs MS-7	◯	○							●						●			
Warm Springs MS-8	○														●			
Bunchgrass Cr																		●
Warm Springs MS-9	○	○													●			
L Deschutes MS-19					●													
Trout Cr-1									●									●
Trout Cr-2									●					●				●
L Deschutes MS-20	○	○			●				●					●				
Shitike Cr-1	○				●		●		●									●

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
◯ ● High	○ ● Medium	○ ● Low	Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Continued next page

Deschutes Westside Summer Steelhead - continued
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Shitike Cr-2	○	○			●		●		●									
Shitike Cr-3	◯	○			●													
L Deschutes MS-21	○	○			●				●					●				●
Pelton Dam complex		◯									●							
M Deschutes MS-4					●				●					●	●	●		●
Metolius MS-1									●					●	●	●		●
Fly Cr-1									●					●	●			●
Metolius MS-2					●				●					●	●	●		●
Spring Cr-1									●					●	●	●		●
Metolius MS-3					●				●					●	●	●		●
Street Cr-1									●					●	●	●		●
Street Cr-2									●									●
Metolius MS-4					●				●					●	●	●		●
Metolius MS-5					●									●				
Whitewater R																		
Metolius MS-6					●									●				
Jefferson Cr																		●
Metolius MS-7														●				●
Candle Cr																		
Metolius MS-8					●				●					●				
Abbot Cr	○														●			
Metolius MS-9					●									●				●
Canyon Cr-1 (Met)																		
Metolius MS-10					●									●				
Jack Cr-1									●									●
Jack Cr-2																		
Metolius MS-11					●				●					●				●
First Cr																		●
Metolius MS-12					●				●					●				
Spring Cr-1 (Met)									●									
Metolius MS-13					●									●				●
Lake Cr MF-1	○				●									●				
Lake Cr SF	○				●									●				
Lake Cr MF-2	○				●									●				
Lake Cr-1	○				●				●					●				●
Metolius MS-14					●				●					●				
M Deschutes MS-5					●				●				●	●		●		●
Crooked MS-1									●					●	●	●		●
M Deschutes MS-6					●				●					●	●	●		●
M Deschutes MS-7					●				●									
Squaw Cr-1	○								●									●
Squaw Cr-2	◯	○												●				●
Indian Ford Cr	○						●								●	●		●
Squaw Cr-3	○						●		●					●				●
Squaw Cr-4																		
Squaw Cr-5	○													●				●
Squaw Cr-6																		
Squaw Cr-7	○	○												●				●
Snow Cr (Squaw)	○																	●
Squaw Cr-8	○																	●
M Deschutes MS-8	○	○			●		●		●					●				●
M Deschutes MS-9																		
M Deschutes MS-10	○				●		●		●					●				●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

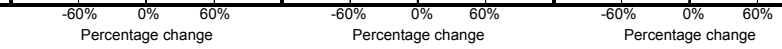
A ◯ ● High
B ○ ● Medium
C ○ ● Low
D & E Indirect or General

Baseline Diagnostic Report – Tornado Chart

Lower John Day Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Bridge Creek	B	6	A	1						
Lower JDR Muddy Creek	B	3	A	5						
Upper Middle JDR	A	2	A	6						
Mountain Creek	B	5	A	4						
Lower JDR Kahler Creek	C	8	A	2						
Rock Creek	A	1	B	12						
Lower JDR Scott Canyon	C	9	A	6						
JDR Johnson Creek	C	9	B	8						
Thirtymile Creek	D	14	A	3						
Butte Creek	C	9	B	9						
Lower JDR McDonald Ferry	B	4	D	18						
Lower JDR Service Creek	D	12	B	10						
Lower JDR Clarno	C	7	D	17						
Upper Rock Creek	D	15	B	10						
Lower JDR Ferry Canyon	D	13	C	15						
Lower Rock Cr	E	16	C	14						
Pine Hollow	E	17	C	13						
Grass Valley Canyon	E	19	D	16						
Lower NF JDR	E	18	E	19						
Fields Creek	E	20	E	20						



Baseline Diagnostic Report – Diagnostic Summary

Lower John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Bridge Creek	○	◯	•				•		●		⬤				⬤	●		⬤
Butte Creek	∘	○	•				•		●				•		⬤	●		⬤
Fields Creek									⬤						•			⬤
Grass Valley Canyon			•				●		•				•	•	⬤	●		●
JDR Johnson Creek	∘	○	•				●		●				•	•	●	●		●
Lower JDR Clarno	∘		•		•				●				•	•	•	●		●
Lower JDR Ferry Canyon		∘	•		•		●		●				•	•	●	●		●
Lower JDR Kahler Creek	∘	◯	•				●		●		⬤		•		●	●		⬤
Lower JDR McDonald Ferry	○				•				⬤					●	⬤	•		●
Lower JDR Muddy Creek	○	◯	•				●		●		⬤		•	•	⬤	●		●
Lower JDR Scott Canyon	∘	◯	•		•		●		●				•	•	⬤	●		●
Lower JDR Service Creek		○	•				●		●				•	•	●	●		⬤
Lower NF JDR									•							●		●
Lower Rock Cr		∘	•				●		●		⬤				⬤	•		●
Mountain Creek	○	◯	⬤				•		●				•		●	●		●
Pine Hollow		∘	•				●		●	•			•		⬤	●		⬤
Rock Creek	◯	○	⬤				•		•		⬤				●	•		●
Thirtymile Creek		◯	•				●		●		⬤		•	•	⬤	⬤		⬤
Upper Middle JDR	◯	◯	•				•		●				•		●	●		●
Upper Rock Creek		○	•				●		●						⬤	●		⬤

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A	B	C	D & E
◯ / ⬤ High	○ / ● Medium	∘ / • Low	Indirect or General

Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Lower John Day Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Upper Rock Creek	D	2	B	7						
Bridge Creek	E	9	A	1						
Butte Creek	E	9	A	2						
Thirtymile Creek	E	9	A	2						
Lower JDR Scott Canyon	D	1	C	12						
Mountain Creek	E	9	A	4						
Lower Rock Cr	E	9	B	5						
Lower JDR Kahler Creek	E	9	B	6						
Rock Creek	E	9	B	8						
JDR Johnson Creek	E	9	B	9						
Lower JDR Muddy Creek	E	5	C	13						
Upper Middle JDR	E	9	B	9						
Lower JDR Ferry Canyon	E	4	C	15						
Lower JDR Service Creek	D	3	D	16						
Pine Hollow	E	9	C	11						
Grass Valley Canyon	E	9	C	14						
Lower JDR Clarno	E	7	D	17						
Lower NF JDR	E	6	E	19						
Fields Creek	E	7	E	20						
Lower JDR McDonald Ferry	E	9	D	18						

-20% 0% 20%
Percentage change

-20% 0% 20%
Percentage change

-20% 0% 20%
Percentage change

Scenario Profile Report – Change in Habitat Factors Summary

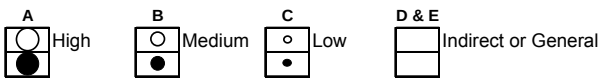
Priority 1 and 2 Subbasin Actions – 100 years

Lower John Day Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Bridge Creek		◯	o				o		o						◯	o		o
Butte Creek		◯	o				o		o						◯	◯		o
Fields Creek									o									o
Grass Valley Canyon		o	o				◯		o						◯	o		o
JDR Johnson Creek		◯	o				o		o				o		o	o		o
Lower JDR Clarno									o				o			o		o
Lower JDR Ferry Canyon		o					o		o				o		◯	o		◯
Lower JDR Kahler Creek		◯	o				o		◯				o		◯	o		o
Lower JDR McDonald Ferry									o						◯	o		
Lower JDR Muddy Creek		o					o		◯				o		◯	o		◯
Lower JDR Scott Canyon		o	o				o		o				o		◯	o		◯
Lower JDR Service Creek							o		o						o	o		o
Lower NF JDR									o							o		o
Lower Rock Cr		◯	o				◯		◯		◯				◯	o		◯
Mountain Creek		◯	◯				o		o						◯	o		◯
Pine Hollow		o	o				◯		o	o			o		◯	◯		◯
Rock Creek		◯	◯						o		◯				◯	o		◯
Thirtymile Creek		◯	o				o		◯		◯		o		◯	◯		◯
Upper Middle JDR		◯	o				o		o						o	o		o
Upper Rock Creek		◯					◯		o						◯	o		◯

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

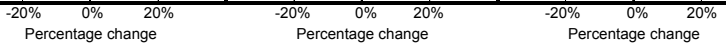
Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

Lower John Day Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Bridge Creek	A	1	A	2						
Upper Rock Creek	A	3	A	2						
Lower JDR Kahler Creek	C	9	A	1						
Upper Middle JDR	A	4	B	6						
Mountain Creek	A	4	B	9						
Rock Creek	A	2	B	11						
Lower JDR Muddy Creek	C	11	B	5						
Lower JDR Scott Canyon	C	13	B	4						
Thirtymile Creek	B	7	B	12						
Butte Creek	B	6	C	14						
JDR Johnson Creek	C	14	B	7						
Lower JDR Ferry Canyon	C	11	B	10						
Lower JDR McDonald Ferry	B	8	D	17						
Lower JDR Service Creek	D	17	B	8						
Lower JDR Clarno	C	14	C	14						
Lower Rock Cr	C	10	D	18						
Pine Hollow	D	16	C	13						
Grass Valley Canyon	D	18	D	16						
Lower NF JDR	E	19	E	19						
Fields Creek	E	20	E	20						



Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

Lower John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Bridge Creek	A	A	B				B		B		A				B	B		A
Butte Creek	B	C					B		B						B	B		A
Fields Creek									A									B
Grass Valley Canyon							B		B					C	B	B		B
JDR Johnson Creek	C	B	B				B		B					C	B	B		B
Lower JDR Clarno	C	C			C				A				C	C	B	B		B
Lower JDR Ferry Canyon	C	B			C		B		A				C	C	B	B		B
Lower JDR Kahler Creek	C	A	B				B		A		A				B	B		A
Lower JDR McDonald Ferry	B				C				A					B	C			B
Lower JDR Muddy Creek	C	B					B		A		A		C	C	B	B		B
Lower JDR Scott Canyon	C	B			C		A		B				C	C	B	B		B
Lower JDR Service Creek		B	B				B		A				C	C	B	B		B
Lower NF JDR									B							B		C
Lower Rock Cr	C						B											B
Mountain Creek	A	B	B				B		B						B	B		B
Pine Hollow		C					B		B						B	B		A
Rock Creek	A	B	B				B		B						B	B		B
Thirtymile Creek	B	B					B		B						B	B		A
Upper Middle JDR	A	B	B				B		B						B	B		B
Upper Rock Creek	A	A					B		B						B	B		B

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

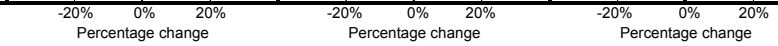
A High B Medium C Low D & E Indirect or General

Baseline Diagnostic Report – Tornado Chart

NF John Day Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
NF JDR Big Creek	A	1	A	4						
Upper NF JDR	A	3	A	3						
NF JDR Potamus Creek	B	5	A	2						
Desolation Creek	A	2	C	8						
Upper Camas Creek	B	4	C	7						
Granite Creek	B	7	B	5						
Wall Creek	B	8	B	6						
Cottonwood Creek	D	16	A	1						
Lower JDR McDonald Ferry	B	6	D	11						
Lower NF JDR	C	10	C	8						
Lower Camas Creek	C	13	C	8						
Lower JDR Kahler Creek	C	9	D	14						
Lower JDR Scott Canyon	C	13	D	13						
Lower JDR Service Creek	C	10	D	16						
Lower JDR Clarno	C	13	D	15						
Lower JDR Ferry Canyon	D	17	D	12						
Lower JDR Muddy Creek	C	12	D	17						
JDR Johnson Creek	E	18	E	18						
Lower MF JDR	E	18	E	18						



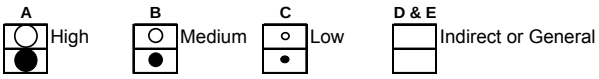
Baseline Diagnostic Report – Diagnostic Summary

NF John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Cottonwood Creek		○	●				●		●				•		●	●		●
Desolation Creek	○	∘	•												●	•		●
Granite Creek	○	○	•				•		•						●			●
JDR Johnson Creek									•					•	•			●
Lower Camas Creek	∘	∘	•				•		●						●	•		●
Lower JDR Clarno	∘								•					•				●
Lower JDR Ferry Canyon									•					•				●
Lower JDR Kahler Creek	∘						•		●							•		●
Lower JDR McDonald Ferry	○								•					●				
Lower JDR Muddy Creek	∘								●					•				●
Lower JDR Scott Canyon	∘								•					•				●
Lower JDR Service Creek	∘						•		●						•	•		●
Lower MF JDR									●							●		•
Lower NF JDR	∘	∘	•				•		●				•		●	●		●
NF JDR Big Creek	○	○	●						•		●				•	•		●
NF JDR Potamus Creek	○	○	•				•		●						●	•		●
Upper Camas Creek	○	∘	•				•		•						●	•		●
Upper NF JDR	○	○	●						•						●	•		●
Wall Creek	○	○					●		•						●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



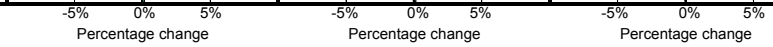
Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

NF John Day Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Upper NF JDR	E	4	A	1						
Cottonwood Creek	E	4	A	2						
Granite Creek	E	4	B	3						
NF JDR Big Creek	E	4	B	3						
Upper Camas Creek	E	4	B	3						
Wall Creek	E	4	B	6						
Desolation Creek	E	4	B	7						
Lower Camas Creek	E	4	B	7						
Lower NF JDR	E	1	C	10						
NF JDR Potamus Creek	E	4	B	9						
Lower JDR McDonald Ferry	E	4	C	10						
Lower JDR Scott Canyon	E	4	D	12						
Lower JDR Kahler Creek	E	4	D	13						
Lower JDR Service Creek	E	4	D	14						
Lower JDR Ferry Canyon	E	4	D	15						
Lower MF JDR	E	1	E	18						
JDR Johnson Creek	E	3	E	17						
Lower JDR Clarno	E	4	D	16						
Lower JDR Muddy Creek	E	4	E	18						



Scenario Profile Report – Change in Habitat Factors Summary

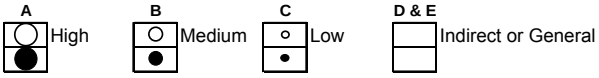
Priority 1 and 2 Subbasin Actions – 100 years

NF John Day Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	**Relative loss**	**Relative gain**	***Channel stability***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Cottonwood Creek		◯	○				∘		∘				∘		◯	◯		◯
Desolation Creek		○	∘												∘			∘
Granite Creek		○	∘						∘						○			∘
JDR Johnson Creek									∘						∘			∘
Lower Camas Creek		○	∘				∘		∘						∘	∘		○
Lower JDR Clarno																		∘
Lower JDR Ferry Canyon																		
Lower JDR Kahler Creek							∘		○							∘		∘
Lower JDR McDonald Ferry		∘																
Lower JDR Muddy Creek									∘									∘
Lower JDR Scott Canyon																		∘
Lower JDR Service Creek									∘									∘
Lower MF JDR									∘							○		
Lower NF JDR		∘	∘						∘						∘	○		∘
NF JDR Big Creek		○	∘													∘		∘
NF JDR Potamus Creek		○							∘						∘	∘		
Upper Camas Creek		○	∘				∘		∘						○	∘		∘
Upper NF JDR		◯	○												∘	∘		
Wall Creek		○					∘		∘						○	○		∘

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

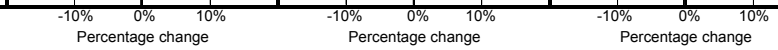
Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

NF John Day Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
NF JDR Potamus Creek	A	2	A	2						
NF JDR Big Creek	A	1	A	4						
Granite Creek	A	4	B	6						
Upper NF JDR	A	6	A	4						
Cottonwood Creek	B	10	A	1						
Wall Creek	B	8	A	3						
Desolation Creek	A	3	B	9						
Upper Camas Creek	A	5	B	8						
Lower JDR McDonald Ferry	B	7	D	11						
Lower NF JDR	C	13	B	6						
Lower Camas Creek	B	10	C	10						
Lower JDR Kahler Creek	B	9	D	12						
Lower JDR Service Creek	C	12	D	15						
Lower JDR Ferry Canyon	C	17	D	12						
Lower JDR Clarno	C	16	D	14						
Lower JDR Scott Canyon	C	15	D	15						
Lower JDR Muddy Creek	C	14	E	17						
Lower MF JDR	D	18	E	18						
JDR Johnson Creek	D	18	E	19						



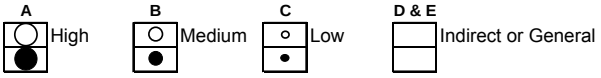
Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

NF John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Cottonwood Creek	○	◯	●				●		●						●	●		⬤
Desolation Creek	◯	○													•			●
Granite Creek	◯	○	●				●		●						●			●
JDR Johnson Creek														•				•
Lower Camas Creek	○	∘	●				●		●						•	•		●
Lower JDR Clarno	∘													•				●
Lower JDR Ferry Canyon	∘								•					•				●
Lower JDR Kahler Creek	○						•		⬤									•
Lower JDR McDonald Ferry	○													⬤				
Lower JDR Muddy Creek	∘								•					•				●
Lower JDR Scott Canyon	∘													•				•
Lower JDR Service Creek	∘								•						•			●
Lower MF JDR									•							•		•
Lower NF JDR	∘	○	●				•		⬤						●	●		●
NF JDR Big Creek	◯	◯	●						•		●				•	•		●
NF JDR Potamus Creek	◯	◯					•		•						•	•		●
Upper Camas Creek	◯	○	●				•		•						•	•		●
Upper NF JDR	◯	◯	●												●			●
Wall Creek	○	◯					•		•						•	⬤		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

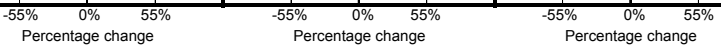


Baseline Diagnostic Report – Tornado Chart

MF John Day Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Big Creek	B	2	A	1						
Camp Creek	A	1	A	2						
Long Creek	C	3	B	3						
Lower JDR McDonald Ferry	C	3	C	6						
Upper MF JDR	C	5	B	5						
Lower MF JDR	D	7	B	4						
Lower JDR Kahler Creek	C	5	D	12						
Lower JDR Clarno	D	10	D	9						
Lower JDR Ferry Canyon	D	12	C	7						
Lower JDR Scott Canyon	D	11	C	8						
Lower JDR Service Creek	D	8	D	13						
Lower NF JDR	D	12	D	9						
Lower JDR Muddy Creek	D	9	D	14						
NF JDR Potamus Creek	D	14	D	11						
Cottonwood Creek	E	15	E	15						
Wall Creek	E	15	E	15						
JDR Johnson Creek	E	15	E	17						



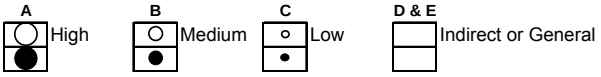
Baseline Diagnostic Report – Diagnostic Summary

MF John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Big Creek	○	◯	•				•		•						●	•		●
Camp Creek	◯	◯	•				•		•						●	•		●
Cottonwood Creek			•				•		•									●
JDR Johnson Creek									•					•	•			●
Long Creek	○	◯	•				●		●						●	•		●
Lower JDR Clarno									•					•				●
Lower JDR Ferry Canyon		○							•					•				●
Lower JDR Kahler Creek	○						•		●							•		●
Lower JDR McDonald Ferry	○	○							•					●				
Lower JDR Muddy Creek									•					•				●
Lower JDR Scott Canyon		○							•					•				●
Lower JDR Service Creek									•					•				●
Lower MF JDR		◯	•				•		●						●	●		●
Lower NF JDR									•							●		●
NF JDR Potamus Creek									●							●		•
Upper MF JDR	○	◯	•				•		•						●			●
Wall Creek							•		•									●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

MF John Day Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Camp Creek	E	6	A	1						
Big Creek	E	6	B	2						
Long Creek	E	6	B	3						
Upper MF JDR	E	6	C	4						
Lower MF JDR	E	6	C	5						
Lower JDR McDonald Ferry	E	6	D	6						
Lower NF JDR	E	2	E	10						
Lower JDR Kahler Creek	E	6	D	7						
Lower JDR Scott Canyon	E	6	D	8						
NF JDR Potamus Creek	E	1	E	13						
Lower JDR Service Creek	E	6	E	9						
Lower JDR Ferry Canyon	E	6	E	11						
Cottonwood Creek	E	3	E	15						
Lower JDR Clarno	E	6	E	12						
Lower JDR Muddy Creek	E	6	E	14						
Wall Creek	E	4	E	16						
JDR Johnson Creek	E	4	E	17						

-25% 0% 25%
Percentage change

-25% 0% 25%
Percentage change

-25% 0% 25%
Percentage change

Scenario Profile Report – Change in Habitat Factors Summary

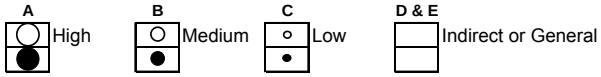
Priority 1 and 2 Subbasin Actions – 100 years

MF John Day Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	**Relative loss**	**Relative gain**	***Channel stability***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Big Creek		○	∘						∘						∘	∘		∘
Camp Creek		◯	∘						∘						◯	∘		∘
Cottonwood Creek			∘				∘		∘									○
JDR Johnson Creek									∘						∘			∘
Long Creek		○	∘				○		∘						◯	∘		○
Lower JDR Clarno																		∘
Lower JDR Ferry Canyon																		
Lower JDR Kahler Creek							∘		○							∘		∘
Lower JDR McDonald Ferry																		
Lower JDR Muddy Creek																		∘
Lower JDR Scott Canyon																		∘
Lower JDR Service Creek																		∘
Lower MF JDR		∘	∘				∘		○						◯	◯		∘
Lower NF JDR									∘							∘		∘
NF JDR Potamus Creek									∘							∘		
Upper MF JDR		∘	∘				∘		∘						◯			∘
Wall Creek									∘									∘

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

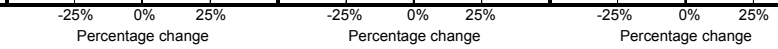
Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

MF John Day Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Big Creek	B	2	A	1						
Camp Creek	A	1	A	2						
Long Creek	B	3	B	4						
Lower JDR McDonald Ferry	C	5	B	5						
Lower MF JDR	C	7	B	3						
Upper MF JDR	B	4	B	6						
Lower JDR Kahler Creek	C	6	D	12						
Lower JDR Clarno	D	11	C	8						
Lower JDR Ferry Canyon	D	13	B	6						
Lower JDR Scott Canyon	D	10	C	11						
Lower JDR Service Creek	D	8	D	13						
Lower NF JDR	D	12	C	9						
Lower JDR Muddy Creek	D	9	D	14						
NF JDR Potamus Creek	D	13	C	10						
Cottonwood Creek	E	15	E	15						
Wall Creek	E	16	E	16						
JDR Johnson Creek	E	16	E	17						



Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

MF John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Big Creek	○	◯	•						•						•	•		●
Camp Creek	◯	◯					•		•						•	•		●
Cottonwood Creek																		•
JDR Johnson Creek														•				•
Long Creek	○	○					•		•						•	•		●
Lower JDR Clarno		○												•				●
Lower JDR Ferry Canyon		◯							•					•				●
Lower JDR Kahler Creek	○								●									•
Lower JDR McDonald Ferry	○	◯												●				
Lower JDR Muddy Creek														•				●
Lower JDR Scott Canyon		○												•				•
Lower JDR Service Creek									•					•				●
Lower MF JDR	○	◯					•		•						●	•		●
Lower NF JDR		○							•									●
NF JDR Potamus Creek		○							●							•		•
Upper MF JDR	○	○	•				•		•						●			●
Wall Creek							•		•									•

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
◯ / ● High	○ / • Medium	○ / • Low	Indirect or General

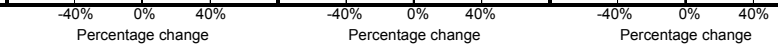
1/ "Channel stability" applies to freshwater areas only.

Baseline Diagnostic Report – Tornado Chart

SF John Day Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Lower SF JDR	A	1	A	1						
Murderers Creek	B	3	B	2						
Middle SF JDR	B	3	C	3						
Lower JDR McDonald Ferry	B	2	D	6						
Lower JDR Kahler Creek	B	3	D	10						
JDR Johnson Creek	C	10	D	4						
Lower JDR Ferry Canyon	C	9	D	7						
Lower JDR Clarno	C	8	D	9						
Lower JDR Service Creek	C	6	D	11						
Upper Middle JDR	D	12	D	5						
Lower JDR Scott Canyon	C	10	D	8						
Lower JDR Muddy Creek	C	7	D	12						
Fields Creek	E	13	D	12						
Rock Creek	E	14	E	14						
Lower NF JDR	E	15	E	14						



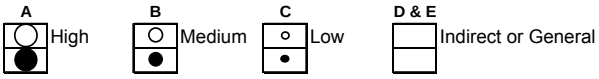
Baseline Diagnostic Report – Diagnostic Summary

SF John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	***Channel stability***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Fields Creek									•					•	•			●
JDR Johnson Creek	○						•		●						•	•		●
Lower JDR Clarno	○								•					•				●
Lower JDR Ferry Canyon	○								•					•				●
Lower JDR Kahler Creek	○								●							•		●
Lower JDR McDonald Ferry	○								•					●				
Lower JDR Muddy Creek	○								•					•				●
Lower JDR Scott Canyon	○								•					•				●
Lower JDR Service Creek	○								•					•				●
Lower NF JDR									•							●		●
Lower SF JDR	◯	◯	•				•		•						●	●		●
Middle SF JDR	○	○	•				•		•						●	•		●
Murderers Creek	○	○	•				•		•						●	•		●
Rock Creek									•							•		●
Upper Middle JDR							•		●							•		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

SF John Day Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Lower SF JDR	E	3	A	1						
Murderers Creek	E	3	A	2						
Middle SF JDR	E	3	B	3						
Upper Middle JDR	E	3	C	4						
JDR Johnson Creek	E	3	C	5						
Lower JDR McDonald Ferry	E	3	D	6						
Lower JDR Kahler Creek	E	3	D	7						
Lower JDR Scott Canyon	E	3	D	8						
Fields Creek	E	3	D	9						
Lower JDR Service Creek	E	3	D	10						
Lower JDR Ferry Canyon	E	3	D	11						
Lower NF JDR	E	1	E	13						
Lower JDR Clarno	E	3	D	12						
Rock Creek	E	1	E	15						
Lower JDR Muddy Creek	E	3	E	14						
					-15% 0% 15%		-15% 0% 15%		-15% 0% 15%	
					Percentage change		Percentage change		Percentage change	

Scenario Profile Report – Change in Habitat Factors Summary

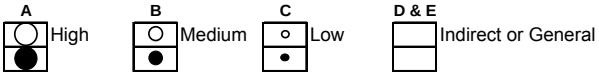
Priority 1 and 2 Subbasin Actions – 100 years

SF John Day Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Fields Creek									o						o			○
JDR Johnson Creek		o							o						o	o		o
Lower JDR Clarno																		o
Lower JDR Ferry Canyon																		
Lower JDR Kahler Creek									○							o		o
Lower JDR McDonald Ferry																		
Lower JDR Muddy Creek																		o
Lower JDR Scott Canyon																		o
Lower JDR Service Creek																		o
Lower NF JDR									o							○		o
Lower SF JDR		◯					o		o						○	○		o
Middle SF JDR		○	o						o						○	o		o
Murderers Creek		◯	o						o						○	o		o
Rock Creek									o							o		o
Upper Middle JDR		o							o									o

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

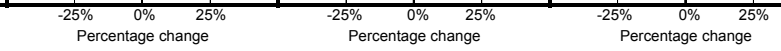
Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

SF John Day Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Lower SF JDR	A	1	A	1						
Murderers Creek	A	2	B	2						
Middle SF JDR	B	3	B	3						
Lower JDR McDonald Ferry	C	4	C	5						
JDR Johnson Creek	C	7	C	4						
Lower JDR Kahler Creek	C	5	C	9						
Lower JDR Scott Canyon	C	9	C	7						
Lower JDR Service Creek	C	6	D	11						
Upper Middle JDR	C	11	C	6						
Lower JDR Muddy Creek	C	7	D	12						
Lower JDR Clarno	C	10	C	10						
Lower JDR Ferry Canyon	C	12	C	8						
Fields Creek	D	13	E	13						
Rock Creek	E	14	E	14						
Lower NF JDR	E	15	E	15						



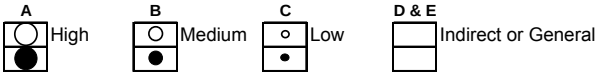
Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

SF John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Fields Creek									•					•				●
JDR Johnson Creek	○	○							•									•
Lower JDR Clarno	○	○												•				●
Lower JDR Ferry Canyon	○	○							•					•				●
Lower JDR Kahler Creek	○	○							●									•
Lower JDR McDonald Ferry	○	○												●				
Lower JDR Muddy Creek	○													•				●
Lower JDR Scott Canyon	○	○												•				•
Lower JDR Service Creek	○								•					•				●
Lower NF JDR									•							•		●
Lower SF JDR	◯	◯					•		•						●	•		●
Middle SF JDR	○	○					•		•						●	•		●
Murderers Creek	◯	○							•						●	•		●
Rock Creek									•									●
Upper Middle JDR	○	○					•		•									●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

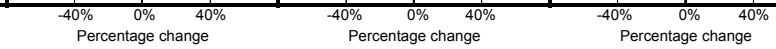


Baseline Diagnostic Report – Tornado Chart

Upper John Day Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Strawberry Creek	B	3	A	2						
Upper JDR	A	1	B	5						
Fields Creek	C	6	A	1						
Canyon Creek	B	2	C	6						
Beech Creek	C	7	B	4						
Lower JDR McDonald Ferry	C	4	D	7						
Laycock Creek	C	9	A	3						
Lower JDR Kahler Creek	C	5	D	13						
Lower JDR Clarno	D	11	D	10						
Lower JDR Scott Canyon	D	12	D	9						
Lower JDR Service Creek	C	7	D	14						
Lower JDR Ferry Canyon	D	14	D	8						
JDR Johnson Creek	D	13	D	11						
Lower JDR Muddy Creek	D	10	D	15						
Upper Middle JDR	E	15	D	12						
Lower SF JDR	E	16	E	16						
Rock Creek	E	17	E	17						



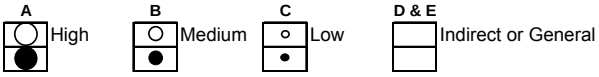
Baseline Diagnostic Report – Diagnostic Summary

Upper John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Beech Creek	○	◯	●				⬤		⬤		⬤				⬤	●		●
Canyon Creek	◯	○	●				•		•						•	•		●
Fields Creek	○	◯	●				•		⬤						⬤	•		⬤
JDR Johnson Creek									⬤						•	•		●
Laycock Creek	○	◯	●				•		⬤		⬤				⬤	•		●
Lower JDR Clarno									•					●				●
Lower JDR Ferry Canyon									•					●				●
Lower JDR Kahler Creek	○								⬤					●		•		●
Lower JDR McDonald Ferry	○								•					⬤				
Lower JDR Muddy Creek									•					●				●
Lower JDR Scott Canyon									•					●				●
Lower JDR Service Creek	○								•					●				●
Lower SF JDR									•						•			●
Rock Creek							•		•							•		●
Strawberry Creek	○	◯	●				•		⬤		⬤				⬤	⬤		●
Upper JDR	◯	○					•		•		⬤				⬤	•		●
Upper Middle JDR							•		⬤							•		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Upper John Day Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Laycock Creek	E	4	A	1						
Strawberry Creek	E	4	B	2						
Beech Creek	E	4	B	3						
Upper JDR	E	4	B	4						
Fields Creek	E	4	C	5						
Canyon Creek	E	4	C	6						
Lower JDR McDonald Ferry	E	4	D	7						
Upper Middle JDR	E	1	D	10						
JDR Johnson Creek	E	4	D	8						
Lower JDR Kahler Creek	E	4	D	8						
Lower JDR Scott Canyon	E	4	D	10						
Lower JDR Service Creek	E	4	E	12						
Lower JDR Ferry Canyon	E	4	E	13						
Lower SF JDR	E	2	E	15						
Lower JDR Clarno	E	4	E	14						
Rock Creek	E	2	E	17						
Lower JDR Muddy Creek	E	4	E	16						

-25% 0% 25% Percentage change

-25% 0% 25% Percentage change

-25% 0% 25% Percentage change

Scenario Profile Report – Change in Habitat Factors Summary

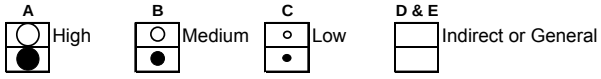
Priority 1 and 2 Subbasin Actions – 100 years

Upper John Day Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	**Relative loss**	**Relative gain**	***Channel stability***	***Chemicals***	***Competition (w/ hatch)***	***Competition (other sp)***	***Flow***	***Food***	***Habitat diversity***	***Harassment/poaching***	***Obstructions***	***Oxygen***	***Pathogens***	***Predation***	***Sediment load***	***Temperature***	***Withdrawals***	***Key habitat quantity***
Beech Creek		C	c				c		c		C				C	C		C
Canyon Creek		c	c				c		c						c	c		c
Fields Creek		c	c				c		C						C	c		C
JDR Johnson Creek									c						c	c		c
Laycock Creek		C	c				c		c		C				C	c		C
Lower JDR Clarno																		c
Lower JDR Ferry Canyon																		
Lower JDR Kahler Creek									C							c		c
Lower JDR McDonald Ferry																		
Lower JDR Muddy Creek																		c
Lower JDR Scott Canyon																		c
Lower JDR Service Creek																		c
Lower SF JDR															c			c
Rock Creek									c							c		c
Strawberry Creek		C	c				c		C		C				C	C		C
Upper JDR		C							c		C				C	c		c
Upper Middle JDR									c									c

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

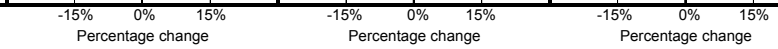
Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)



Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

Upper John Day Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
Strawberry Creek	B	2	A	2						
Canyon Creek	B	3	B	4						
Laycock Creek	B	4	B	3						
Fields Creek	C	7	A	1						
Upper JDR	A	1	B	7						
Beech Creek	B	5	B	5						
Lower JDR McDonald Ferry	C	6	B	5						
Lower JDR Kahler Creek	C	8	C	12						
Lower JDR Service Creek	C	9	C	11						
Lower JDR Clarno	C	12	C	9						
Lower JDR Scott Canyon	C	11	C	10						
Lower JDR Ferry Canyon	C	14	C	8						
Lower JDR Muddy Creek	C	10	C	14						
JDR Johnson Creek	C	13	C	13						
Upper Middle JDR	C	14	C	15						
Lower SF JDR	D	16	D	16						
Rock Creek	D	17	D	17						



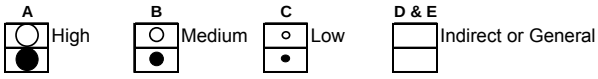
Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

Upper John Day Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Beech Creek	○	○	●				●		●						●	●		●
Canyon Creek	○	○	●						●									●
Fields Creek	∘	◯	●				●		●						●			●
JDR Johnson Creek	∘	∘							●									●
Laycock Creek	○	○					●		●						●			●
Lower JDR Clarno	∘	∘												●				●
Lower JDR Ferry Canyon	∘	∘							●					●				●
Lower JDR Kahler Creek	∘	∘							●									●
Lower JDR McDonald Ferry	∘	○												●				
Lower JDR Muddy Creek	∘	∘												●				●
Lower JDR Scott Canyon	∘	∘												●				●
Lower JDR Service Creek	∘	∘							●					●				●
Lower SF JDR																		●
Rock Creek									●									●
Strawberry Creek	○	◯	●				●		●						●	●		●
Upper JDR	◯	○							●						●			●
Upper Middle JDR	∘	∘					●		●									●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

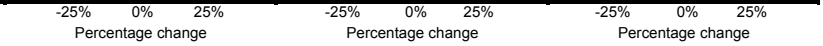


Baseline Diagnostic Report – Tornado Chart

Umatilla Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
GA40	A	1	B	4						
GA28	C	10	A	2						
GA33	B	8	B	5						
GA35	B	5	C	10						
GA19	B	6	C	11						
GA12	C	18	A	1						
GA36	C	14	B	6						
GA42	A	2	C	22						
GA43	B	7	C	18						
GA15	C	19	B	7						
GA18	C	12	C	18						
GA46	B	4	C	26						
GA9	C	13	C	20						
GA14	C	15	C	20						
GA44	B	3	D	32						
GA20	D	24	C	12						
GA17	D	25	C	14						
GA45	C	11	C	28						
GA2	C	16	C	24						
GA34	C	17	C	23						
GA5	E	37	A	3						
GA13	E	33	C	9						
GA32	D	30	C	13						
GA1	D	21	C	26						
GA37	C	9	D	38						
GA21	E	42	B	7						
GA27	E	33	C	16						
GA29	E	33	C	16						
GA31	D	28	C	24						
GA38	D	23	C	29						
GA4	E	38	C	15						
GA16	D	20	D	35						
GA39	D	26	D	31						
GA6	D	29	C	29						
GA41	D	21	D	40						
GA25	D	27	D	35						
GA30	D	30	D	34						
GA11	E	32	D	39						
GA8	E	39	D	33						
GA3	E	36	E	41						
GA7	E	41	D	37						
GA26	E	40	E	42						
GA22	E	42	E	43						
GA24	E	42	E	43						



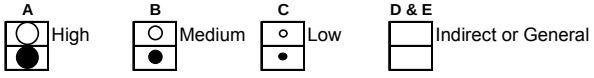
Baseline Diagnostic Report – Diagnostic Summary

Umatilla Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
GA1		○	●		●		●		●					●	⬤	●		●
GA2	○	○	●		●		●		●				●	●	⬤	●		
GA3			●				⬤		⬤						⬤			⬤
GA4		○	⬤				⬤		⬤	●					⬤	⬤		⬤
GA5		◯	⬤				⬤		⬤	●	⬤		●		⬤	⬤		⬤
GA6		○	●				⬤		⬤	●					⬤			⬤
GA7			⬤				●		●				●		⬤	⬤		⬤
GA8			⬤				●		●				●		⬤	⬤		⬤
GA9	○	○	●		●		●		⬤					●	⬤	●		
GA11			●		●		●		●					●	●	●		
GA12	○	◯	⬤				●		●		⬤		●		⬤	⬤		⬤
GA13		○	⬤				⬤		⬤	●	⬤		●		⬤	⬤		⬤
GA14	○	○	⬤				●		●						⬤	⬤		⬤
GA15	○	○	⬤				●		●		⬤				⬤	⬤		⬤
GA16			⬤				●		●							●		⬤
GA17		○	⬤				●		●	●					⬤	⬤		⬤
GA18	○	○	⬤				●		●						⬤	●		⬤
GA19	○	○	●				●		●							●		⬤
GA20		○	●				●		●	⬤				●	⬤	●		⬤
GA21		○	⬤				●		⬤		⬤		⬤	●	⬤	⬤		⬤
GA22			⬤				●		●				●			⬤		⬤
GA24			⬤				●		●							⬤		⬤
GA25			●		●		●		●					●	⬤	●		
GA26			●				●		●						⬤	⬤		●
GA27		○	⬤				⬤		●						⬤	⬤		●
GA28	○	◯	⬤		●		●		●				●	●	⬤	⬤		●
GA29		○	●				●		●				●		⬤	⬤		⬤
GA30			⬤				●	●	●							⬤		⬤
GA31		○	⬤				●	●							⬤	⬤		⬤
GA32		○	⬤				●	●	●						⬤	⬤		⬤
GA33	○	○	⬤		●		●	●	●					●		⬤		⬤
GA34	○	○	⬤		●		●		●					●	●			●
GA35	○	○	●		●		●		●		⬤			●		●		●
GA36	○	○	⬤		●		●		●					●		⬤		⬤
GA37	○		●		●		●		●					●				⬤
GA38		○	⬤		●		●		⬤					●	⬤			⬤
GA39			●		●		●				●			●	⬤			⬤
GA40	◯	○	⬤				●		●							⬤		●
GA41			⬤				●	●	●									⬤
GA42	◯	○	⬤															
GA43	○	○	⬤				●	●	●									
GA44	○		●				●											
GA45	○	○	⬤				●	●	●									⬤
GA46	○	○	⬤				●		●									

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.



Scenario Profile Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

Umatilla Summer Steelhead
Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
GA28	E	10	A	1						
GA12	E	10	A	2						
GA40	E	10	A	3						
GA33	E	10	A	4						
GA5	C	1	B	13						
GA36	E	10	B	5						
GA13	E	10	B	6						
GA15	E	10	B	7						
GA17	E	10	B	8						
GA19	E	10	B	9						
GA32	E	10	B	10						
GA14	E	10	B	11						
GA18	E	10	B	12						
GA2	E	10	B	14						
GA43	E	10	B	15						
GA1	E	10	C	16						
GA31	E	10	C	16						
GA4	E	4	C	23						
GA9	E	10	C	18						
GA27	E	5	C	24						
GA35	E	10	C	19						
GA38	E	10	C	20						
GA20	E	10	C	21						
GA8	E	7	C	24						
GA45	E	10	C	22						
GA29	C	1	C	32						
GA42	E	10	C	24						
GA6	E	8	C	27						
GA46	E	10	C	27						
GA25	C	1	D	37						
GA7	E	9	C	29						
GA16	E	10	C	29						
GA30	E	10	C	29						
GA11	E	10	D	33						
GA34	E	10	D	34						
GA39	E	10	D	34						
GA44	E	10	D	36						
GA26	E	6	D	41						
GA3	E	10	D	38						
GA37	E	10	D	38						
GA41	E	10	D	40						
GA21	E	10	E	42						
GA22	E	10	E	42						
GA24	E	10	E	42						
					-10% 0% 10%		-10% 0% 10%		-10% 0% 10%	
					Percentage change		Percentage change		Percentage change	

Scenario Profile Report – Change in Habitat Factors Summary

Priority 1 and 2 Subbasin Actions – 100 years

Umatilla Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario																
Geographic area	Relative loss	Relative gain	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
GA1		○													◯	○		◯
GA2		◯							○		○		○		◯	○		●
GA3							○		◯						◯			○
GA4		○	○				○		◯	○					◯	◯		◯
GA5	●	◯	◯				○		◯	○	◯		○		◯	◯		◯
GA6		○	○				○		○						◯			◯
GA7		○	○										○		◯	◯		◯
GA8		○	◯				○		○						◯	◯		○
GA9		○							◯						◯			●
GA11																○		●
GA12		◯	◯				○		○		◯		○		○	◯		◯
GA13		◯	◯				◯		◯	○	◯		○		○	◯		◯
GA14		◯	○				○		○						○	○		◯
GA15		◯	◯				○		○		◯				◯	◯		◯
GA16		○	○				○											◯
GA17		◯	◯				○		○	○					○	◯		◯
GA18		◯	◯				○		○						○	○		◯
GA19		◯	○				○		○									◯
GA20		○	○						○	○					○			◯
GA21			○				○		◯				○		◯	◯		○
GA22			◯				○		○							○		◯
GA24			○				○		○							◯		◯
GA25	●						○		○						◯	○		●
GA26							○		○						◯	○		●
GA27		○	◯				○		○						◯	◯		●
GA28		◯	◯				○		○				○	○	○	◯		●
GA29	●	○					○		○						◯	◯		○
GA30		○	◯				○		○							◯		◯
GA31		○	◯				○								◯	◯		◯
GA32		◯	◯				○		○						◯	◯		○
GA33		◯	◯				○		○							◯		◯
GA34			○												○			○
GA35		○	○						○							○		●
GA36		◯	◯				○		○							◯		◯
GA37			○															◯
GA38		○	◯				○		◯						◯			◯
GA39															◯			◯
GA40		◯	◯				○		○							◯		●
GA41			○						○									●
GA42		○	○															○
GA43		◯	◯				○		○									●
GA44			○															
GA45		○	◯						○									○
GA46		○	○													●		

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

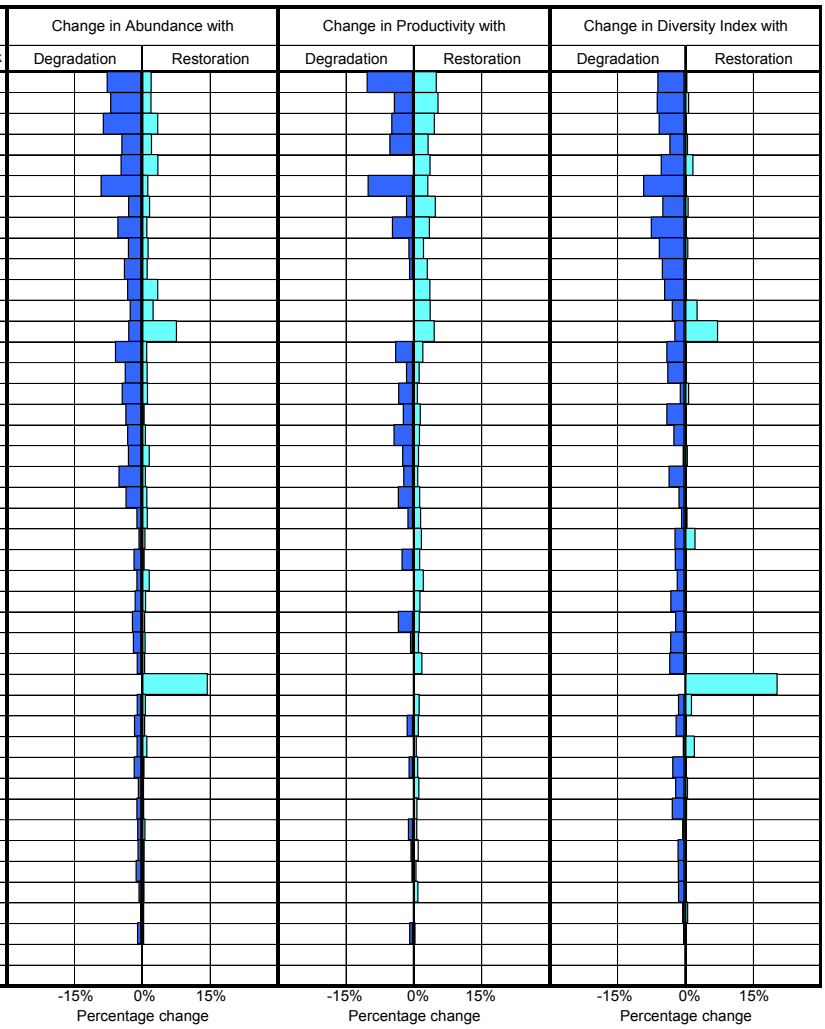
Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)

A ◯/● High B ○/● Medium C ○/• Low D & E Indirect or General

Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

Umatilla Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit	
	Category	rank	Category	rank
GA28	A	2	B	6
GA12	A	5	B	4
GA33	A	3	B	9
GA9	A	7	B	7
GA8	B	12	B	3
GA40	A	1	B	15
GA15	B	15	B	5
GA19	A	4	B	18
GA35	B	13	B	10
GA36	B	11	B	12
GA6	B	16	B	8
GA7	C	23	B	2
GA5	C	25	A	1
GA42	A	6	C	23
GA46	B	10	C	25
GA2	B	17	C	20
GA14	B	9	C	29
GA18	B	13	C	27
GA1	C	24	B	17
GA44	B	8	C	33
GA43	B	18	C	25
GA25	D	30	B	14
GA29	D	33	B	12
GA13	C	20	C	28
GA20	D	32	B	16
GA34	C	27	C	21
GA17	C	19	C	32
GA45	C	21	C	30
GA32	C	28	C	24
GA21	E	42	B	11
GA27	D	35	C	19
GA16	C	26	C	34
GA4	D	38	C	22
GA37	C	22	C	40
GA39	D	34	C	30
GA38	C	29	C	37
GA11	D	35	C	35
GA31	D	35	C	36
GA41	D	31	D	42
GA30	D	38	C	39
GA26	E	41	C	38
GA3	D	38	D	41
GA22	E	42	E	43
GA24	E	42	E	43



Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

Umatilla Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
GA1	○	◯	●		●									●	●	●		
GA2	◯	○	●		●				●					●	●			
GA3							●		⬤						⬤			●
GA4		○	●				●		⬤	●					⬤	⬤		⬤
GA5	○	◯	⬤				●		⬤	●			●		⬤	⬤		⬤
GA6	◯	◯	●				●		●	●					⬤			⬤
GA7	○	◯	⬤				●						●		⬤	⬤		●
GA8	◯	◯	⬤				●		●						⬤	●		●
GA9	◯	◯			●				●					●				
GA11		○			●									●				
GA12	◯	◯					●								●	⬤		●
GA13	○	○	●													⬤		
GA14	◯	○	●				●								●	●		●
GA15	◯	◯	●				●		●						●	⬤		⬤
GA16	○	○	●				●											⬤
GA17	○	○														⬤		●
GA18	◯	○	●				●		●						●	●		●
GA19	◯	◯					●		●									●
GA20		◯	●				●		●	●				●	●	●		⬤
GA21		◯	●				●		⬤		⬤		●		⬤	⬤		⬤
GA22			⬤				●		●							⬤		⬤
GA24			⬤				●		●							⬤		⬤
GA25		◯			●		●		●					●	●	●		
GA26		○					●		●						⬤	●		
GA27		○	⬤				●		●						⬤	⬤		●
GA28	◯	◯			●									●		⬤		
GA29		◯	●				●		●						⬤	⬤		●
GA30		○	●				●	●	●							⬤		●
GA31		○	●													⬤		●
GA32	○	○	●				●									⬤		●
GA33	◯	◯	●		●									●		●		⬤
GA34	○	○	●		●		●		●					●				●
GA35	◯	◯			●						⬤			●		●		●
GA36	◯	◯	●		●									●		⬤		●
GA37	○	○	●		●		●							●				⬤
GA38	○	○	●		●									●	⬤			⬤
GA39		○	●		●						●			●	⬤			⬤
GA40	◯	◯														⬤		
GA41			●				●		●									⬤
GA42	◯	○	●															●
GA43	◯	○						●										
GA44	◯	○																
GA45	○	○					●	●										●
GA46	◯	○																

Key to strategic priority (corresponding Benefit Category letter also shown)

A ◯/⬤ High B ○/● Medium C ○/● Low D & E Indirect or General

1/ "Channel stability" applies to freshwater areas only.

Baseline Diagnostic Report – Tornado Chart

Walla Walla Summer Steelhead

Relative Importance Of Geographic Areas For Protection and Restoration Measures - current condition

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category/rank		Category/rank		Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
SF Walla Walla, mouth to Elbow Creek	B	4	A	3						
SF Walla Walla, Elbow to access limit	A	1	B	11						
NF Walla Walla, mouth to L. Meadows Cr	D	11	B	4						
Walla Walla, Little Walla Walla Diversion	C	6	B	9						
Mill Cr, Blue Cr to Walla Walla water intak	C	7	B	10						
Walla Walla, E Little Walla Walla to Tuma	C	8	B	11						
Cottonwood Cr Drainage (including NF, S	E	15	B	5						
Pine Cr mainstem (plus Swartz)	E	17	B	5						
Lower Walla Walla (mouth to Touche)	E	28	A	1						
Mill Cr, Gose Street to Bennington Dam	E	28	A	1						
NF Walla Walla, L. Meadows to access lin	C	9	C	20						
Walla Walla, Touche to Dry (plus Mud Cr	E	21	B	8						
Walla Walla, Tumalum Bridge to Nursery	E	13	C	19						
E Little Walla Walla Drainage (plus Unnar	E	24	B	11						
Walla Walla, Mill to E L. Walla Walla (plus	E	28	B	7						
Mill Cr, mouth to start of Corps Project at	E	20	C	16						
Mill Cr, Walla Walla water intake to acces	C	5	D	34						
Walla Walla, Nursery Br to Little Walla W	E	14	C	25						
Garrison Cr Drainage (plus Bryant)	E	25	C	16						
Upper SF Walla Walla tribs (excluding Sk	B	2	E	39						
Skiphorton & Reser Creek Drainages	B	3	E	39						
Yellowhawk mainstem (mouth to source)	E	28	C	14						
Dry Cr [Pine] Drainage	E	28	C	15						
Lower Dry Cr (mouth to Sapolil)	E	19	C	24						
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF D	E	16	C	28						
Upper Dry Cr (Sapolil to forks)	E	22	C	22						
Lower Mill Cr Tribs (Doan & Cold)	E	18	C	27						
Lower SF Walla Walla Tribs (Flume Cany	C	9	E	36						
Walla Walla, Dry to Mill	E	28	C	18						
Upper Mill Tribs (NF, Low, Broken, Parad	D	12	E	37						
Yellowhawk Tribs (Lassater, Russell, Res	E	28	C	21						
Mill Cr, Bennington Dam to Blue Cr (plus T	E	23	C	28						
W Little Walla Walla Drainage (plus Wals	E	28	C	23						
Stone Cr Drainage	E	28	C	26						
Blue Cr Drainage (including L. Blue)	E	28	D	30						
Couse Creek Drainage	E	28	D	30						
Birch Creek Drainage	E	27	D	33						
Middle Mill Cr Tribs (Henry Canyon, Webb	E	25	D	35						
Lower Touche (mouth to Coppei)	E	28	E	38						

-50% 0% 50%
Percentage change

-50% 0% 50%
Percentage change

-50% 0% 50%
Percentage change

Baseline Diagnostic Report – Diagnostic Summary

Walla Walla Summer Steelhead
Protection and Restoration Strategic Priority Summary - current condition

Geographic area priority			Attribute class priority for restoration															
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Lower Walla Walla (mouth to Touche)		◯	●	•	●		●	•	●				●	●	●	●	•	•
Lower Touche (mouth to Coppei)			•		•		•		•					•	●	•	•	●
Walla Walla, Touche to Dry (plus Mud Cr)		○	•				●	•	●				●	•	●	●		●
Pine Cr mainstem (plus Swartz)		○	•				●		●		•		•		●	•		●
Dry Cr [Pine] Drainage		○	•		•		●	•	●	•			•		●	●		●
Lower Dry Cr (mouth to Sapolil)		○	•		•		●		●		●		•		●	●	•	•
Upper Dry Cr (Sapolil to forks)		○	•		•		•		•		●				●	●		•
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF Dry & SF D		○	●		•		●		●	•	●				●	●		•
Walla Walla, Dry to Mill		○	•		•		●		●	•			•	●	●	●	●	
W Little Walla Walla Drainage (plus Walsh)		○	•				●		●				•		●	●		●
Mill Cr, mouth to start of Corps Project at Gose St		○	•		•		●		●	•			•		●	●	•	●
Lower Mill Cr Tribs (Doan & Cold)		○	●				●		●	•	●				●	●	•	●
Mill Cr, Gose Street to Bennington Dam		◯	•		•		●	•	●	•	●		•		●	●		●
Mill Cr, Bennington Dam to Blue Cr (plusTitus)		○	•		•		●		●		●		•		●	●	•	●
Blue Cr Drainage (including L. Blue)			●				●		●				•		●	●		●
Mill Cr, Blue Cr to Walla Walla water intake	○	○	•				•		•						●	•		●
Middle Mill Cr Tribs (Henry Canyon, Webb &Tiger)			●				•		•									•
Mill Cr, Walla Walla water intake to access limit	○																	•
Upper Mill Tribs (NF, Low, Broken, Paradise)															•			●
Walla Walla, Mill to E L. Walla Walla (plus MacAvo		○	●				●		●	•			•		●	●		•
Garrison Cr Drainage (plus Bryant)		○	•		•		●	•	●	•	●		•		●	●		●
Stone Cr Drainage		○	●		•		●	•	●	●	●		•		●	●		●
E Little Walla Walla Drainage (plus Unnamed Sprin		○	•		•		●	•	●	•	•				●	•		●
Walla Walla, E Little Walla Walla to Tumalum Bridg	○	○	●				●		•	•					●	●		
Yellowhawk mainstem (mouth to source)		○	•		•		•		●	•			•		●	●		
Yellowhawk Tribs (Lassater, Russell, Reser & Cald		○	●				●		●	•	●				●	●		●
Cottonwood Cr Drainage (including NF, SF & MF)		○	●				●		●				•		●	●		●
Birch Creek Drainage			•				●	•	●	•	•		•		●	●		●
Walla Walla, Tumalum Bridge to Nursery Bridge		○	●				●	•	●	●					•	•		●
Walla Walla, Nursery Br to Little Walla Walla Diver		○	●				●	•	●	•					•			●
Walla Walla, Little Walla Walla Diversion to forks	○	○	•				•		●	•					•			●
Couse Creek Drainage			●				●		●	•		●	•		●	●		●
NF Walla Walla, mouth to L. Meadows Canyon Cr (		○	●				●		●						●	●		●
NF Walla Walla, L. Meadows to access limit (plus E	○	○	●				•		•						•			
SF Walla Walla, mouth to Elbow Creek	○	◯	•				●		●						●	●		●
Lower SF Walla Walla Tribs (Flume Canyon, Elbow	○		●												●			●
SF Walla Walla, Elbow to access limit	◯	○																
Upper SF Walla Walla tribs (excluding Skiphorton &	○																	
Skiphorton & Reser Creek Drainages	○																	

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A	B	C	D & E
◯ / ● High	○ / ● Medium	○ / • Low	Indirect or General

Scenario Profile Report – Tornado Chart

Priority 1 and 2 Subbasin Actions – 100 years

Walla Walla Summer Steelhead

Change in Performance Due to Scenario's Effect within Geographic Area

Geographic Area	Loss category		Gain category		Loss or Gain in Abundance		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Loss	Gain	Loss	Gain	Loss	Gain
Cottonwood Cr Drainage (including NF, S	E	4	C	10						
Pine Cr mainstem (plus Swartz)	E	3	D	14						
SF Walla Walla, mouth to Elbow Creek	E	17	A	1						
NF Walla Walla, mouth to L. Meadows Cr	E	17	B	2						
E Little Walla Walla Drainage (plus Unnar	E	10	C	10						
Lower Walla Walla (mouth to Touche)	E	17	B	3						
Walla Walla, Little Walla Walla Diversion	E	17	B	4						
Walla Walla, Tumalum Bridge to Nursery	E	17	B	5						
Walla Walla, Nursery Br to Little Walla W	E	17	C	6						
Walla Walla, Touche to Dry (plus Mud Cr	E	17	C	7						
Dry Cr [Pine] Drainage	E	7	D	18						
Walla Walla, E Little Walla Walla to Tuma	E	17	C	8						
Couse Creek Drainage	C	1	E	25						
NF Walla Walla, L. Meadows to access lir	E	17	C	9						
Mill Cr, mouth to start of Corps Project at	E	6	D	21						
Upper SF Walla Walla tribs (excluding Sk	C	1	E	27						
SF Walla Walla, Elbow to access limit	E	17	D	12						
W Little Walla Walla Drainage (plus Wals	E	13	D	16						
Walla Walla, Mill to E L. Walla Walla (plus	E	17	D	12						
Mill Cr, Bennington Dam to Blue Cr (plus T	E	9	D	21						
Mill Cr, Blue Cr to Walla Walla water intak	E	15	D	15						
Skiphorton & Reser Creek Drainages	E	4	E	27						
Mill Cr, Gose Street to Bennington Dam	E	7	E	27						
Walla Walla, Dry to Mill	E	17	D	17						
Lower SF Walla Walla Tribs (Flume Cany	E	17	D	19						
Birch Creek Drainage	E	11	E	26						
Middle Mill Cr Tribs (Henry Canyon, Webf	E	14	D	23						
Upper Mill Tribs (NF, Low, Broken, Paradi	E	17	D	20						
Mill Cr, Walla Walla water intake to acces	E	17	E	24						
Yellowhawk mainstem (mouth to source)	E	15	E	27						
Blue Cr Drainage (including L. Blue)	E	17	E	27						
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF D	E	17	E	27						
Garrison Cr Drainage (plus Bryant)	E	17	E	27						
Lower Dry Cr (mouth to Sapolil)	E	17	E	27						
Lower Mill Cr Tribs (Doan & Cold)	E	17	E	27						
Lower Touche (mouth to Coppei)	E	17	E	27						
Stone Cr Drainage	E	17	E	27						
Upper Dry Cr (Sapolil to forks)	E	17	E	27						
Yellowhawk Tribs (Lassater, Russell, Res	E	17	E	27						

-20% 0% 20% Percentage change

-20% 0% 20% Percentage change

-20% 0% 20% Percentage change

Scenario Profile Report – Change in Habitat Factors Summary

Priority 1 and 2 Subbasin Actions – 100 years

Walla Walla Summer Steelhead
Summary of Scenario Effects on Survival Factors and Overall Performance

Relative loss or gain by area			Change in attribute impact on survival due to scenario															
Geographic area	Relative loss	Relative gain	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Lower Walla Walla (mouth to Touche)		○					∘						∘		◯	∘		•
Lower Touche (mouth to Coppei)																		
Walla Walla, Touche to Dry (plus Mud Cr)		∘					∘						∘		◯	∘		∘
Pine Cr mainstem (plus Swartz)			∘				∘		∘		○				○	∘		○
Dry Cr [Pine] Drainage			∘				∘		∘				∘		∘	○		◯
Lower Dry Cr (mouth to Sapolil)																		
Upper Dry Cr (Sapolil to forks)																		
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF Dry & SF D																		
Walla Walla, Dry to Mill							∘						∘		∘	∘		•
W Little Walla Walla Drainage (plus Walsh)							∘		∘						◯	○		○
Mill Cr, mouth to start of Corps Project at Gose St							∘								○			∘
Lower Mill Cr Tribs (Doan & Cold)																		
Mill Cr, Gose Street to Bennington Dam							∘								◯			○
Mill Cr, Bennington Dam to Blue Cr (plusTitus)															∘	∘		∘
Blue Cr Drainage (including L. Blue)																		
Mill Cr, Blue Cr to Walla Walla water intake															∘	∘		∘
Middle Mill Cr Tribs (Henry Canyon, Webb &Tiger)			∘															
Mill Cr, Walla Walla water intake to access limit																		
Upper Mill Tribs (NF, Low, Broken, Paradise)															∘			
Walla Walla, Mill to E L. Walla Walla (plus MacAvo							∘								○	○		•
Garrison Cr Drainage (plus Bryant)																		
Stone Cr Drainage																		
E Little Walla Walla Drainage (plus Unnamed Sprin		∘	∘				○		○						◯	∘		◯
Walla Walla, E Little Walla Walla to Tumalum Bridg		∘	∘				∘		∘						○	○		●
Yellowhawk mainstem (mouth to source)																		
Yellowhawk Tribs (Lassater, Russell, Reser & Cald																		
Cottonwood Cr Drainage (including NF, SF & MF)		∘	∘				∘		∘						○	○		◯
Birch Creek Drainage			∘				∘		○		∘		∘		○	∘		◯
Walla Walla, Tumalum Bridge to Nursery Bridge		○	◯				○		◯	○					∘	∘		●
Walla Walla, Nursery Br to Little Walla Walla Divers		∘	○				○		◯	○					∘			●
Walla Walla, Little Walla Walla Diversion to forks		○	∘				∘		○	∘					∘			●
Couse Creek Drainage	•		∘				∘		∘			◯	∘		∘	◯		◯
NF Walla Walla, mouth to L. Meadows Canyon Cr (		○	○				∘		○						○	○		○
NF Walla Walla, L. Meadows to access limit (plus E		∘	∘						∘						∘			
SF Walla Walla, mouth to Elbow Creek		◯	∘				○		○						○	○		○
Lower SF Walla Walla Tribs (Flume Canyon, Elbow			○												○	•		◯
SF Walla Walla, Elbow to access limit																		
Upper SF Walla Walla tribs (excluding Skiphorton &	•																	
Skiphorton & Reser Creek Drainages																•		

Key to amount of change in factor (corresponding Loss/Gain Category letter also shown)

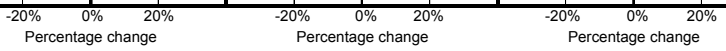
A ◯/● High B ○/● Medium C ∘/• Low D & E □ Indirect or General

1/ Greatest absolute value of factor change (whether gain or loss) is shown for area (reaches may differ in gain or loss).

Scenario Diagnostic Report – Tornado Chart
Priority 1 and 2 Subbasin Actions – 100 years

Walla Walla Summer Steelhead
Relative Importance Of Geographic Areas For Protection and Restoration Measures After Scenario Implementation

Geographic Area	Protection benefit		Restoration benefit		Change in Abundance with		Change in Productivity with		Change in Diversity Index with	
	Category	rank	Category	rank	Degradation	Restoration	Degradation	Restoration	Degradation	Restoration
SF Walla Walla, Elbow to access limit	A	1	B	11						
Cottonwood Cr Drainage (including NF, S	D	16	B	2						
Pine Cr mainstem (plus Swartz)	C	15	B	4						
Walla Walla, E Little Walla Walla to Tuma	C	7	C	16						
Walla Walla, Mill to E L. Walla Walla (plus	D	21	B	2						
Mill Cr, Blue Cr to Walla Walla water intak	C	13	B	11						
Dry Cr [Pine] Drainage	D	18	B	8						
NF Walla Walla, mouth to L. Meadows Cr	C	3	D	23						
E Little Walla Walla Drainage (plus Unnar	C	14	C	15						
NF Walla Walla, L. Meadows to access lir	C	10	C	20						
Mill Cr, mouth to start of Corps Project at	D	23	B	10						
Walla Walla, Touche to Dry (plus Mud Cr	E	29	B	6						
Walla Walla, Dry to Mill	E	31	B	5						
Couse Creek Drainage	D	19	C	18						
Lower SF Walla Walla Tribs (Flume Cany	C	8	D	30						
SF Walla Walla, mouth to Elbow Creek	B	2	E	36						
Yellowhawk mainstem (mouth to source)	E	30	B	8						
Lower Walla Walla (mouth to Touche)	E	38	A	1						
Walla Walla, Little Walla Walla Diversion	C	3	E	38						
Walla Walla, Tumalum Bridge to Nursery	C	6	E	35						
W Little Walla Walla Drainage (plus Wals	D	21	C	21						
Yellowhawk Tribs (Lassater, Russell, Res	D	25	C	17						
Mill Cr, Bennington Dam to Blue Cr (plus T	D	19	D	24						
Mill Cr, Walla Walla water intake to acces	C	11	E	32						
Upper Dry Cr (Sapolil to forks)	D	24	C	19						
Upper SF Walla Walla tribs (excluding Sk	C	5	E	38						
Lower Dry Cr (mouth to Sapolil)	E	34	B	11						
Mill Cr, Gose Street to Bennington Dam	E	38	B	7						
Walla Walla, Nursery Br to Little Walla W	C	8	E	38						
Skiphorton & Reser Creek Drainages	C	12	E	37						
Garrison Cr Drainage (plus Bryant)	E	37	C	14						
Upper Mill Tribs (NF, Low, Broken, Parad	D	17	E	34						
Lower Mill Cr Tribs (Doan & Cold)	D	26	D	27						
Birch Creek Drainage	D	27	D	28						
Stone Cr Drainage	E	35	C	21						
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF D	E	32	D	25						
Middle Mill Cr Tribs (Henry Canyon, Webb	D	27	D	31						
Blue Cr Drainage (including L. Blue)	E	36	D	26						
Lower Touche (mouth to Coppei)	E	38	E	33						



Scenario Diagnostic Report – Diagnostic Summary
Priority 1 and 2 Subbasin Actions – 100 years

Walla Walla Summer Steelhead
Protection and Restoration Strategic Priority Summary After Scenario Implementation

Geographic area priority			Attribute class priority for restoration																
Geographic area	Protection benefit	Restoration benefit	Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Lower Walla Walla (mouth to Touche)		◯	●	•	●		●	•	●				●	●	●	●	•	
Lower Touche (mouth to Coppei)			•		•		•		•					•	●	•	•	●
Walla Walla, Touche to Dry (plus Mud Cr)		◯	•				●	•	●				•	•	●	●		●
Pine Cr mainstem (plus Swartz)	○	◯	•				•		●						●	•		●
Dry Cr [Pine] Drainage		◯	•				●		●	•					●	●		●
Lower Dry Cr (mouth to Sapolil)		◯	•		•		●		●		●		•		●	●	•	•
Upper Dry Cr (Sapolil to forks)		○	•		•		•		•		●				●	●		•
Dry Cr Tribs (Mud[Dixie], Mud[Dry], NF Dry & SF Dry)			●		•		●		●	•	●				●	●		•
Walla Walla, Dry to Mill		◯	•		•		●		●	•			•	●	●	●	●	
W Little Walla Walla Drainage (plus Walsh)		○	•				●		•				•		●	●		●
Mill Cr, mouth to start of Corps Project at Gose St		◯	•		•		●		●	•			•		●	●	•	●
Lower Mill Cr Tribs (Doan & Cold)			●				●		●	•	●				●	●	•	●
Mill Cr, Gose Street to Bennington Dam		◯	•		•		●	•	●	•	●				●	●		●
Mill Cr, Bennington Dam to Blue Cr (plusTitus)			•		•		●		●		●				●	●	•	●
Blue Cr Drainage (including L. Blue)			●				●		●				•		●	●		●
Mill Cr, Blue Cr to Walla Walla water intake	○	◯	•				•		•						●	•		●
Middle Mill Cr Tribs (Henry Canyon, Webb &Tiger)			●				•		•									•
Mill Cr, Walla Walla water intake to access limit	○																	
Upper Mill Tribs (NF, Low, Broken, Paradise)															•			●
Walla Walla, Mill to E L. Walla Walla (plus MacAvoy &		◯	•				•		●	•					●	●		•
Garrison Cr Drainage (plus Bryant)		○	•		•		●	•	●	•	●		•		●	●		●
Stone Cr Drainage		○	●		•		●	•	●	●	●		•		●	●		●
E Little Walla Walla Drainage (plus Unnamed Spring &	○	○	•				•		•		•				●			●
Walla Walla, E Little Walla Walla to Tumalum Bridge	○	○	•				•		•						●	•		•
Yellowhawk mainstem (mouth to source)		◯	•		•		•		●	•			•		●	●		
Yellowhawk Tribs (Lassater, Russell, Reser & Caldwel		○	●				●		●	•	●				●	●		●
Cottonwood Cr Drainage (including NF, SF & MF)		◯	●				•		•						●	●		•
Birch Creek Drainage			•				●		●	•					●	●		●
Walla Walla, Tumalum Bridge to Nursery Bridge	○																	●
Walla Walla, Nursery Br to Little Walla Walla Diversion	○																	●
Walla Walla, Little Walla Walla Diversion to forks	○																	●
Couse Creek Drainage		○	•				•		•			•			•	•		•
NF Walla Walla, mouth to L. Meadows Canyon Cr (plu	○		•															●
NF Walla Walla, L. Meadows to access limit (plus Big	○	○	•				•		•									
SF Walla Walla, mouth to Elbow Creek	◯																	●
Lower SF Walla Walla Tribs (Flume Canyon, Elbow)	○		●												•			●
SF Walla Walla, Elbow to access limit	◯	◯																
Upper SF Walla Walla tribs (excluding Skiphorton & R	○																	
Skiphorton & Reser Creek Drainages	○																	

Key to strategic priority (corresponding Benefit Category letter also shown)

A	B	C	D & E
◯ High	○ Medium	○ Low	Indirect or General
●	●	•	

1/ "Channel stability" applies to freshwater areas only.

Appendix H

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APPENDIX I

Oregon Mid-Columbia Steelhead
Cost Estimates for Recovery Actions

Cost Estimates for Recovery Actions
Draft – 9 October 2007

Introduction

The ESA section 4(f)(1) requires that recovery plans include "estimates of the time required and the cost to carry out those measures needed to achieve the Plan's goal and to achieve intermediate steps toward that goal" (16 U.S.C. 1531-1544, as amended). This draft appendix is intended to meet this ESA requirement and will be used by NMFS to estimate the total recovery costs for the Mid-Columbia steelhead DPS in its draft Mid-Columbia Steelhead DPS Plan.

The Oregon Department of Fish and Wildlife (ODFW), together with its Recovery Planning Team, Management Action Teams, and the Oregon Mid-Columbia River Sounding Board have developed an extensive list of projects needed to recover the Oregon populations in the Mid-Columbia steelhead DPS. These projects are intended to address the recovery of ESA-listed Mid-Columbia River steelhead. The project list was developed using the most up-to-date assessment of Mid-Columbia steelhead recovery needs, without consideration of cost or potential funding. This draft appendix provides cost estimates for each project where available information was sufficient to do so.

Methods and Data

The basic approach taken to estimate the cost of each project was to combine estimates of the scale of the project and the cost per scalar unit for that type of project. This method is known as the unit cost method, and it is appropriate when approximate estimates are sufficient. The estimation took the following steps:

1. Actions listed in Section 9 of the draft Mid-Columbia Steelhead DPS Plan were grouped into a set of project types (*e.g.*, bank stabilization and exclusion fencing). In some cases, the actions listed in Section 9 differed only in minor variations in wording; in other cases, actions had more significant descriptive variations but could still be linked to a standard project type.
2. The scale for each action listed in Section 9 was determined using information in that section or supplemental information provided by ODFW. Scale was measured in two basic ways:

    a. Stream miles of treatment, taken from the EDT analysis used in the recovery plan; or
    b. Number of structures, taken from Section 9 of the recovery plan or provided by ODFW.

    In a few cases, the scale of an action was not used in the cost estimation, as the action was unique to a particular location (*e.g.*, Phase III of the Umatilla Basin Project). For

some actions, no scale estimate is available at this time, in which case no cost estimate is provided in this draft appendix.

3. The unit cost of a project type was estimated using cost data from existing habitat restoration projects and professional judgment. These costs reflected the materials and labor needed to implement a project (see step #4 for additional costs). Three sets of data were used to support the estimation of unit costs:

    a. Habitat restoration project costs in the Oregon portion of the NMFS Interior Columbia recovery domain and in adjacent Washington subbasins. The cost data were drawn from three funding sources: the Oregon Watershed Enhancement Board (OWEB) grant program, the Grande Ronde Model Watershed Program (GRMWP), and the Washington State Salmon Recovery Funding Board (SRFB) grant program. This data set included approximately 1400 individual habitat restoration projects. Projects that included only one type of activity were then analyzed to estimate the unit cost of that activity.
    b. GRMWP unit cost estimates. For a limited number of project types, the GRMWP estimated unit costs of their projects (personal communication, Cecilia Noyes, GRMWP).
    c. SRFB unit costs. As part of the SRFB grant process, applicants provide the SRFB with estimates of the unit costs for various project types. Unit cost estimates were drawn from SRFB projects in the Washington portion of the NMFS Interior Columbia recovery domain for this dataset.

    The three data sources provided different amounts of coverage for the full set of project types constructed in the first step and in a few cases (*e.g.*, land acquisition and water rights transfers), they did not have sufficient data to support the estimation of unit costs. Where the data were judged to be sufficient in quantity and quality, professional judgment was used to develop a unit cost estimate, favoring the mid-point of a range across data sources and projects (where a valid range existed) and rounding appropriately to avoid a false sense of precision.

4. Finally, the resulting total cost estimate was multiplied by 1.6 to reflect the additional costs of project planning, coordination, engineering, permits, and so forth. The multiplier was estimated after consulting with ODFW and other parties experienced in habitat restoration project implementation.

Cost Estimates for Recovery Actions

Table I-1 provides cost estimates for all recovery actions by population, strategy, and category of action. The action categories are the following:

- Baseline: These are the actions categorized as part of an ongoing, existing program. No cost estimate is provided for these actions.
- Cost estimate exists: These are actions for which a estimate and scale are available.

- TBD: These are actions that do not have cost estimates at this time and that are listed as To Be Determined (TBD). The reason for the TBD status is indicated in the following way:
    - TBD (1): In these cases, costs need to be developed for specific sites and projects.
    - TBD (2): These are actions for which a unit cost estimate exists but for which no scale (stream miles or project inventory) is available.
    - TBD (3): These are actions for which a unit cost estimate needs to be developed. These actions may also need a scale estimate.

The Action name is taken from Section 9 of the draft Mid-Columbia Steelhead DPS Plan. The Total Cost Estimate columns are the following:

- P1 miles: Cost estimate for the Priority 1 stream miles used in the EDT analysis.
- P1-2 miles: Cost estimate for the Priority 1 and Priority 2 stream miles used in the EDT analysis.
- Projects: Cost estimate for the number of structures (screens, culverts, etc.) identified for that action and population.

If an action is categorized as Baseline, the cost estimate is listed as N/A (Not Applicable). The cost estimates for P1 miles and P1-2 miles are cumulative (P1 cost estimate < P1-2 cost estimate) and should not be added together. The Projects cost estimate can be added to either the P1 miles estimate or the P1-2 estimate.

Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Table I-2 provides information on current expenditures and expected five year budget amounts for habitat projects by a wide range of local, state, and federal agencies and NGOs. This table provides context for the estimated costs of recovery actions and provides a basis for estimating possible levels of funding for recovery plan implementation over a given period of time.

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
Deschutes River Eastside				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Develop new and manage existing habitat Cooperative Agreements	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect and conserve rare and unique functioning habitats	TBD (3)		
	Protect the highest quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Baseline	Maintain irrigation diversions and screens	N/A		
Cost estimate exists	Culverts: Replace or remove barriers blocking passage including dams, road culverts, irrigation structures, infiltration galleries	$0	$0	$160,000
	Provide screening at 100% of irrigation diversions	$0	$0	$0
TBD	Dams: Replace or remove barriers blocking passage including dams, road culverts, irrigation structures, infiltration galleries	TBD (2)		
	Irrigation Structures: Replace or remove barriers blocking passage including dams, road culverts, irrigation structures, infiltration galleries	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$4,893,840	$8,897,760	$0
	Reconnect side channels and off-channel habitats to stream channels	$4,893,840	$8,897,760	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Increase role and abundance of wood and large organic debris in streambeds	$743,821	$743,821	$0
	Restore natural channel form, includes berm and levee removal	$4,893,840	$8,897,760	$0
	Stabilize streambanks with passive restoration processes	$4,893,840	$8,897,760	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Install off-stream livestock watering	$0	$0	$0
	Install/maintain fencing to exclude livestock from riparian areas	$724,320	$2,516,734	$0
	Restore natural riparian communities	$1,957,536	$4,530,120	$0
TBD	Eradicate invasive plant species from riparian areas	TBD (2)		
	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Monitor/regulate water withdrawals	N/A		
Cost estimate exists	Water retention structures	$316,324	$197,702	$0
TBD	Lease or purchase water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Continue TMDL monitoring	N/A		
	Implement Agricultural Water Quality Management Plan	N/A		
	Manage irrigation return flow to reduce extreme stream temperatures	N/A		
	Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	N/A		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Convert to perennial crops/vegetation (CRP)	N/A		
	Employ BMPs to minimize unnatural rates of erosion	N/A		
	Promote reforestation and fuels management	N/A		
TBD	Achieve 95% conversion to no till farming	TBD (2)		
	Remove junipers	TBD (2)		
	Restore native upland plants and remove noxious weeds	TBD (2)		
	Upgrade or remove problem forest roads	TBD (2)		
Deschutes River Westside				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Adopt and manage Cooperative Agreements	N/A		
	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Special management designations on public lands	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect and conserve rare and unique functioning habitats	TBD (3)		
	Protect the highest quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Baseline	Restore passage at Pelton-Round Butte Complex	N/A		
Cost estimate exists	Culverts: Replace barriers blocking passage including dams, road culverts and irrigation structures	$0	$0	$0
	Provide screening at 100% of irrigation diversions	$0	$0	$0
	Replace screens that do not meet criteria	$0	$0	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Dams: Replace barriers blocking passage including dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Replace barriers blocking passage including dams, road culverts and irrigation structures	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$5,407,200	$25,249,680	$0
	Reconnect side channels and off-channel habitats to stream channels	$5,407,200	$25,249,680	$0
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Increase role and abundance of wood and large organic debris in streambeds	$875,197	$2,308,992	$0
	Restore natural channel form	$5,407,200	$25,249,680	$0
	Stabilize streambanks	$5,407,200	$25,249,680	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Install fencing to exclude livestock from riparian areas	$0	$153,920	$0
	Install off-stream livestock watering	$0	$0	$0
	Plant riparian vegetation where appropriate	$1,120,933	$1,120,933	$0
	Restore natural riparian communities	$372,384	$9,351,936	$0
TBD	Eradicate invasive plant species from riparian areas	TBD (2)		
	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Lease or purchase water rights and convert to instream	TBD (3)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Continue TMDL monitoring	N/A		
	Implement Agricultural Water Quality Management Plan	N/A		
	Manage irrigation return flow to reduce extreme stream temperatures	N/A		
	Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	N/A		
TBD	Reduce chemical pollution inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to minimize unnatural rates of erosion	N/A		
	Utilize appropriate fire suppression techniques	N/A		
TBD	Achieve 95% conversion to no till farming	TBD (2)		
	Restore native upland plants	TBD (2)		
	Upgrade or remove problem forest roads	TBD (2)		
Fifteenmile				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect and conserve rare and unique functioning habitats	TBD (3)		
	Protect the highest quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Cost estimate exists	Culverts: Replace barriers blocking passage including dams, road culverts and irrigation structures	$0	$0	$480,000
	Provide screening at 100% of irrigation diversions	$0	$0	$0
	Replace screens that do not meet criteria	$0	$0	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Dams: Replace barriers blocking passage including dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Replace barriers blocking passage including dams, road culverts and irrigation structures	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$779,528	$912,978	$0
	Reconnect side channels and off-channel habitats to stream channels	$5,846,464	$6,847,336	$0
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Increase role and abundance of wood and large organic debris in streambeds	$622,397	$622,397	$0
	Restore natural channel form	$5,846,464	$6,847,336	$0
	Stabilize streambanks	$9,620,850	$9,620,850	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Install fencing to exclude livestock from riparian areas	$638,230	$825,006	$0
	Install off-stream livestock watering	$438,365	$541,992	$0
	Plant riparian vegetation where appropriate	$0	$0	$0
	Restore natural riparian communities	$1,148,814	$1,485,011	$0
TBD	Eradicate invasive plant species from riparian areas	TBD (2)		
	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Implement urban conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Finish piping Orchard Ridge and Wolf Run diversions	TBD (1)		
	Lease or purchase water rights and convert to instream	TBD (3)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Continue TMDL monitoring	N/A		
	Implement Agricultural Water Quality Management Plan	N/A		
	Manage irrigation return flow to reduce extreme stream temperatures	N/A		
	Minimize unnatural factors that lead to fluctuations in dissolved oxygen levels	N/A		
TBD	Reduce chemical pollution inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Convert to perennial crops/vegetation	N/A		
	Develop Integrated Fruit Production (IFPnet) plans	N/A		
	Employ BMPs to minimize unnatural rates of erosion	N/A		
	Promote fuel management	N/A		
TBD	Initiate demonstration projects	TBD (1)		
	Achieve 95% conversion to no till farming	TBD (2)		
	Upgrade or remove problem forest roads	TBD (2)		
Lower John Day				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Adopt and manage Cooperative Agreements	N/A		
	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Designate additional wilderness and wild and scenic status	N/A		
	Protect access to key habitats	N/A		
	Special management designations in forest and BLM plans	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect high quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
Cost estimate exists	Culverts: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$6,560,000
	Provide screening at 100% of irrigation diversions	$0	$0	$640,000
	Replace screens that do not meet criteria	$0	$0	$400,000
TBD	Dams: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Remove or minimize use of push up dams	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$15,839,274	$21,082,046	$0
	Reconnect side channels and off-channel habitats to stream channels	$9,583,718	$21,082,046	$0
TBD	Restore wet meadows	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Place stable wood and other large organic debris in streambeds	$1,102,763	$2,459,573	$0
	Restore natural channel form	$7,165,397	$21,082,046	$0
	Stabilize streambanks	$11,271,989	$21,082,046	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Restore natural riparian vegetative communities	$6,148,883	$17,121,854	$0
TBD	Develop grazing strategies that promote riparian recovery	TBD (3)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Lease or acquire water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Apply BMPs to animal feeding operations	N/A		
	Continue TMDL monitoring	N/A		
Cost estimate exists	Increase riparian shading	$2,273,984	$4,507,195	$0
TBD	Reduce chemical pollution inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
TBD	Initiate demonstration projects	TBD (1)		
	Continue to promote no-till farming or other seeding techniques that reduce erosion where site conditions and technology are suitable	TBD (2)		
	Manage vegetation, including juniper removal	TBD (2)		
	Restore native upland plant communities	TBD (2)		
	Upgrade or remove problem forest roads	TBD (2)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
Middle Fork John Day				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Adopt and manage Cooperative Agreements	N/A		
	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Designate additional wilderness and wild and scenic status	N/A		
	Protect access to key habitats	N/A		
	Special management designations in forest and BLM plans	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect and conserve rare and unique functioning habitats	TBD (3)		
	Protect high quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Cost estimate exists	Culverts: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$18,320,000
	Replace screens that do not meet criteria	$0	$0	$560,000
TBD	Construct ladders over existing permanent concrete or earth fill dams	TBD (2)		
	Dams: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Remove or minimize use of push up dams	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$5,430,067	$6,017,350	$0
	Reconnect side channels and off-channel habitats to stream channels	$5,430,067	$6,017,350	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Restore wet meadows	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Place stable wood and other large organic debris in streambeds and in floodplains	$316,626	$704,531	$0
	Restore natural channel form	$4,889,888	$5,665,810	$0
	Stabilize streambanks	$2,340,901	$5,477,170	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Restore natural riparian vegetative communities	$2,542,437	$5,262,030	$0
TBD	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Increase pool habitat (beaver ponds)	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Lease or acquire water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Apply BMPs to animal feeding operations	N/A		
	Continue TMDL monitoring	N/A		
	Manage return flow to reduce extreme stream temperatures	N/A		
Cost estimate exists	Increase riparian shading	$891,400	$1,489,614	$0
TBD	Reduce chemical pollution and nutrient inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
Cost estimate exists	Upgrade or remove problem forest roads	$1,060,800	$1,060,800	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Initiate demonstration projects	TBD (1)		
	Manage vegetation, including juniper removal	TBD (2)		
	Restore native upland plant communities	TBD (2)		
North Fork John Day				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Adopt and manage Cooperative Agreements	N/A		
	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Designate additional wilderness and wild and scenic status	N/A		
	Protect access to key habitats	N/A		
	Special management designations in forest and BLM plans	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect high quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Cost estimate exists	Culverts: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$16,000,000
	Provide screening at 100% of irrigation diversions	$0	$0	$120,000
TBD	Construct ladders over existing permanent concrete or earth fill dams, or remove the barrier	TBD (2)		
	Dams: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Remove or minimize use of push up dams	TBD (2)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$2,104,989	$3,364,150	$0
	Reconnect side channels and off-channel habitats to stream channels and reconnect surface flow/restore fish passage in tributaries.	$2,237,203	$3,364,150	$0
TBD	Restore wet meadows	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Place stable wood and other large organic debris in streambeds and in floodplains	$504,664	$1,157,562	$0
	Restore natural channel form	$2,082,064	$3,364,150	$0
	Stabilize streambanks	$775,710	$1,766,690	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Restore natural riparian vegetative communities	$2,108,218	$3,116,517	$0
TBD	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Increase pool habitat (beaver ponds)	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Lease or acquire water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Apply BMPs to animal feeding operations	N/A		
	Continue TMDL monitoring	N/A		
	Manage return flow to reduce extreme stream temperatures	N/A		
Cost estimate exists	Increase riparian shading	$679,021	$1,704,357	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Address contamination from mine related discharge	TBD (1)		
	Reduce chemical pollution inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
Cost estimate exists	Upgrade or remove problem forest roads	$707,200	$707,200	$0
TBD	Initiate demonstration projects	TBD (1)		
	Manage vegetation, including juniper removal	TBD (2)		
	Restore native upland plant communities	TBD (2)		
South Fork John Day				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Adopt and manage Cooperative Agreements	N/A		
	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Designate additional wilderness and wild and scenic status	N/A		
	Protect access to key habitats	N/A		
	Special management designations in forest and BLM plans	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect high quality habitats through acquisition or conservation easements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Cost estimate exists	Culverts: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$5,520,000
	Provide screening at 100% of irrigation diversions	$0	$0	$0
	Replace screens that do not meet criteria	$0	$0	$160,000

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Construct ladders over existing permanent concrete or earth fill dams	TBD (2)		
	Dams: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Remove or minimize use of push up dams	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$0	$275,830	$0
	Reconnect side channels and off-channel habitats to stream channels	$0	$275,830	$0
TBD	Restore wet meadows	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Place stable wood and other large organic debris in streambeds and in floodplains	$205,523	$205,523	$0
	Restore natural channel form	$0	$275,830	$0
	Stabilize streambanks	$0	$0	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Restore natural riparian vegetative communities	$926,317	$1,234,920	$0
TBD	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Increase pool habitat (beaver ponds)	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Lease or acquire water rights and convert to instream	TBD (3)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Apply BMPs to animal feeding operations	N/A		
	Continue TMDL monitoring	N/A		
	Manage return flow to reduce extreme stream temperatures	N/A		
Cost estimate exists	Increase riparian shading	$94,026	$532,170	$0
TBD	Reduce chemical pollution and nutrient inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
TBD	Initiate demonstration projects	TBD (1)		
	Manage vegetation, including juniper removal	TBD (2)		
	Restore native upland plant communities	TBD (2)		
	Upgrade or remove problem forest roads	TBD (2)		
Umatilla				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Continue existing protections and/or increase protection of Federal lands; implement Forest Practices Act and PACFISH/INFISH	N/A		
	Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function	N/A		
	Explore opportunities to incorporate priority areas into state legislation.	N/A		
	Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance	N/A		
	Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues.	N/A		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect high quality habitats through acquisition, conservation easements and cooperative agreements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Baseline	Operate and Maintain fish passage facilities to meet criteria	N/A		
Cost estimate exists	Construct ladders over existing permanent concrete or earth fill dams	$0	$0	$1,600,000
	Culverts: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$800,000
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$2,880,000
	Provide screening at 100% of irrigation diversions	$0	$0	$0
	Replace screens that do not meet criteria	$0	$0	$0
TBD	Dams: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Cost estimate exists	Reconnect floodplains to channels	$5,595,674	$5,595,674	$0
	Reconnect side channels and off-channel habitats to stream channels	$5,595,674	$5,595,674	$0
TBD	Remove dikes and levies	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Place stable wood and other large organic debris in streambeds	$1,067,592	$1,067,592	$0
	Restore natural channel form	$4,966,422	$6,089,248	$0
	Stabilize and protect streambanks	$5,019,445	$5,019,445	$0
TBD	Construct rock and log weirs to create pool habitats or elevate incised channels	TBD (2)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Baseline	Maintain existing widths of RHCAs on USFS lands.	N/A		
Cost estimate exists	Develop no-cultivation riparian buffer on agricultural lands and establish riparian setbacks for structures in areas where activities could upset riparian function	$263,339	$263,339	$0
	Restore natural riparian vegetative communities	$3,701,598	$3,701,598	$0
	Riparian exclosure fencing	$1,890,197	$1,890,197	$0
TBD	Close, remove, and restore riparian road prisms	TBD (2)		
	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Implement Umatilla Basin Project Phase I and II	TBD (1)		
	Implement Umatilla Basin Project Phase III	TBD (3)		
	Downstream water rights transfers	TBD (3)		
	File for additional ISWRs	TBD (3)		
	Lease or acquire water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Implement water quality management plans	N/A		
TBD	Address point sources of water pollution	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
TBD	Restore native upland plant communities	TBD (2)		
	Initiate demonstration projects	TBD (1)		
	Upgrade or remove problem forest roads	TBD (2)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
Upper John Day				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Adopt and manage Cooperative Agreements	N/A		
	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Designate additional wilderness and wild and scenic status	N/A		
	Protect access to key habitats	N/A		
	Special management designations in forest and BLM plans	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect high quality habitats through acquisition or conservation easements	TBD (3		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Cost estimate exists	Culverts: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	$0	$0	$8,800,000
	Provide screening at 100% of irrigation diversions	$0	$0	$1,560,000
	Replace screens that do not meet criteria	$0	$0	$1,880,000
TBD	Construct ladders over existing permanent concrete or earth fill dams	TBD (2)		
	Dams: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, road culverts and irrigation structures	TBD (2)		
	Remove or minimize use of push up dams	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$4,459,760	$4,459,760	$0
	Reconnect side channels and off-channel habitats to stream channels	$6,132,419	$7,431,558	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Restore wet meadows	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Cost estimate exists	Place stable wood and other large organic debris in streambeds	$357,072	$1,082,350	$0
	Restore natural channel form	$7,520,379	$9,277,286	$0
	Stabilize streambanks	$4,459,760	$5,496,088	$0
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Restore natural riparian vegetative communities	$2,337,970	$5,731,272	$0
TBD	Develop grazing strategies that promote riparian recovery	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Implement agricultural water conservation measures	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Increase pool habitat (beaver ponds)	N/A		
	Monitor/regulate water withdrawals	N/A		
TBD	Lease or acquire water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Apply BMPs to animal feeding operations	N/A		
	Continue TMDL monitoring	N/A		
	Manage return flow to reduce extreme stream temperatures	N/A		
Cost estimate exists	Increase riparian shading	$1,787,741	$2,324,475	$0
TBD	Reduce chemical pollution and nutrient inputs	TBD (1)		
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Employ BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
Cost estimate exists	Upgrade or remove problem forest roads	$104,000	$104,000	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Initiate demonstration projects	TBD (1)		
	Manage vegetation, including juniper removal	TBD (2)		
	Restore native upland plant communities	TBD (2)		
Walla Walla				
1. Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle.				
Baseline	Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.	N/A		
	Continue existing protections and/or increase protection of Federal lands; implement Forest Practices Act and PACFISH/INFISH	N/A		
	Establish setbacks to protect waterways from forest management, agricultural activities, and other land use practices that would disrupt ecosystem function	N/A		
	Explore opportunities to incorporate priority areas into state legislation.	N/A		
	Incorporate priority habitat areas into the Natural Area Overlay Zone provision of the Umatilla County Development Ordinance	N/A		
	Review, modify and enforce existing land use planning documents and ordinances pertaining to riparian and floodplain management to better address habitat and water quality issues.	N/A		
Cost estimate exists	Conduct outreach to resource users and managers	$0	$0	$176,000
TBD	Protect and conserve rare and unique functioning habitats	TBD (3)		
	Protect high quality habitats through acquisition, conservation easements and cooperative agreements	TBD (3)		
2. Restore passage and connectivity to habitats blocked or impaired by artificial barriers and maintain unimpaired passage and connectivity.				
Baseline	Operate and Maintain fish passage facilities	N/A		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
Cost estimate exists	Construct ladders over existing permanent irrigation diversions	$0	$0	$1,760,000
	Culverts: Remove or replace barriers blocking passage such as dams, bridges, road culverts and irrigation structures	$0	$0	$1,760,000
	Irrigation Structures: Remove or replace barriers blocking passage such as dams, bridges, road culverts and irrigation structures	$0	$0	$0
	Provide screening at 100% of irrigation diversions	$0	$0	$0
	Replace screens that do not meet criteria	$0	$0	$0
TBD	Dams: Remove or replace barriers blocking passage such as dams, bridges, road culverts and irrigation structures	TBD (2)		
3. Restore floodplain connectivity and function and maintain unimpaired connectivity and function.				
Baseline	Promote the maintenance and creation of beaver dams to restore the role in natural ecological processes.	N/A		
Cost estimate exists	Reconnect floodplains to channels	$1,969,200	$2,589,120	$0
	Reconnect side channels and off-channel habitats to stream channels	$1,969,200	$7,197,120	$0
TBD	Remove dikes and levies	TBD (2)		
4. Restore degraded channel structure and complexity and maintain unimpaired structure and complexity.				
Baseline	Implement bridge maintenance BMPs	N/A		
Cost estimate exists	Place stable wood and other large organic debris in streambeds	$302,064	$302,064	$0
	Restore natural channel form	$2,589,120	$7,197,120	$0
	Stabilize and protect streambanks	$2,589,120	$7,197,120	$0
TBD	Construct rock and log weirs to create pool habitats or elevate incised channels	TBD (2)		
5. Restore riparian condition and LWD recruitment and maintain unimpaired conditions.				
Cost estimate exists	Develop no-cultivation riparian buffer on agricultural lands and establish riparian setbacks for structures in areas where activities could upset riparian function	$129,456	$359,856	$0
	Restore natural riparian vegetative communities	$1,035,648	$2,878,848	$0
	Riparian exclosure fencing	$575,360	$1,599,360	$0

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
TBD	Close, remove, and restore riparian road prisms	TBD (2)		
	Develop grazing strategies that promote riparian recovery	TBD (3)		
	Protect high quality riparian habitats and unstable areas	TBD (3)		
6. Restore natural hydrograph to provide sufficient flow during critical periods.				
Baseline	Close areas to appropriation of new water uses	N/A		
	Improve irrigation conveyance and efficiency	N/A		
	Investigate feasibility of water storage or exchange to improve instream flows for steelhead	N/A		
	Monitor/regulate water withdrawals	N/A		
	Set criteria to protect flows for fish habitat from new appropriations	N/A		
TBD	Aquifer storage and recovery	TBD (1)		
	Enhance hyporheic flows and spring inputs	TBD (1)		
	Implement shallow aquifer recharge	TBD (1)		
	Downstream water rights transfers	TBD (3)		
	File for additional ISWRs	TBD (3)		
	Lease or acquire water rights and convert to instream	TBD (3)		
7. Improve degraded water quality and maintain unimpaired water quality.				
Baseline	Implement pest management plans for fruit growers	N/A		
	Implement water quality management plans	N/A		
	Improve municipal stormwater management and treatment	N/A		
	Permit and enforce actions that could affect water quality	N/A		
	Permit waterway alteration activities and enforce rules	N/A		
TBD	Address point sources of water pollution	TBD (1)		

Table I-1: All Actions by Population, Strategy, and Category				
Population, Strategy, Category	**Action name**	**Total Cost Estimate**		
		P1 miles	**P1-2 miles**	**Projects**
8. Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain unimpaired natural upland processes.				
Baseline	Apply BMPs to forest practices, livestock grazing, road management and agricultural practices	N/A		
TBD	Implement CREP and CCRP buffers	TBD (3)		
	Initiate demonstration projects	TBD (1)		
	Restore native upland plant communities	TBD (2)		
	Upgrade or remove problem forest roads	TBD (2)		

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
Fifteenmile Creek Population				
CTWSRO	CREP	$10,000/yr	$50,000	
	Fifteenmile habitat program		100,000	Coordinate LWD, riparian exclosures, riparian plantings
Wasco Co. SWCD	Riparian buffers	$103,000/yr	$500,000	Funds are for technical work. USDA Farm Services Agency and OWEB leveraging technical dollars under CREP program.
	No-till conversion	$40,000/yr	$100,000	Nearing saturation/completion
	Irrigation efficiency	$30,000/yr	150,000	
	Fish habitat	$125,000/yr	$250,000	eliminate passage barriers, add rootwads, jhooks, eliminate fords
USFS	Fish habitat – Fifteenmile Cr	$25,000/yr		Partner in project
ODFW	Fish Habitat- Fifteenmile Cr	$322,662/yr	$1,600,000	Riparian exclosures, off channel water, instream habitat, M&E
	Fish Screening	$200,000/yr	$800,000	New construction and O&M
Totals - **Fifteenmile Creek Population**		$855,662/yr	$3,550,000	
Eastside Deschutes River Population				
USFS	Fish habitat - Trout Cr	$30,000/yr	$150,000	Partner in project
	Culvert Replacements	$75,000/yr	$500,000	
	Trout Creek (2)			
	Dick Creek			
Sherman County SWCD	CREP	$300,000/yr	$1,250,000	Depends on program availability, Includes rental payments, installed practices, maintenance, etc.
	Habitat	$20,000/yr	$100,000	Passive restoration projects, i.e. off-stream water, tree planting
	Upland	$155,000/yr	$775,000	Erosion control structures, pasture fencing, brush control, range reseeding, etc.

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
Jefferson SWCD	Trout Creek Watershed Improvement and CREP – Fish Habitat	$395,000/yr		Phase 3 Trout Creek Channel Habitat Improvement Project – Channel Reconstruction Project
	Trout Creek Watershed Improvement & CREP– Fish Habitat		$650,000	Antelope Creek Channel Habitat Improvement Project & CREP – 2 miles
	IWM		$500,000	Irrigation Improvement Projects
Deschutes River Conservancy	Instream habitat restoration	$15,000/yr	$75,000	
PGE	Fish habitat – Trout Cr Ranch	$75,000/yr	$950,000	PGE-managed project
	Fish habitat – Trout Cr	$300,000 in 2006	$600,000	Funding of projects. PGE spent $300,000 funding 3 projects in 2006.
Wasco Co. SWCD	Riparian buffers	$40,000/yr	$200,000	Funds are for technical work. USDA Farm Services Agency and OWEB are leveraging the technical dollars under the CREP program.
	Upland conservation	$120,000/yr	$400,000	
ODFW	Fish habitat – Trout Creek	$335,000/yr	$1,750,000	Riparian exclosures, off channel water developments, berm removal/channel reconstruction work.
	Fish screening and passage- Trout Creek	$100,000/yr	$500,000	New construction and O&M
BLM	Upland and riparian weed treatment	$36,000/yr	$180,000	
	Stream and riparian restoration	$29,000/yr	$150,000	Includes maintenance work on existing projects
Totals - **Eastside Deschutes River Population**		$2,025,000/yr	$8,730,000	
Westside Deschutes River Population				
USFS	Fish habitat - Whychus Cr	$30,000/yr	$150,000	Partner in project
	Fish habitat – Metolius R	$25,000/yr	$150,000	Partner in project

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
	Culvert Replacements in Metolius River Watershed	$100,000/yr	$150,000	Lake Creek, Roaring Creek and Bear Valley Creek
CTWSRO	Reservation Watershed maintenance (Shitike, Warm Springs rivers)	$46,000/yr	$750,000	Implementing and maintaining riparian exclosures, solar jacks, off channel water sources.
	Fish habitat (Beaver Creek, Whychus, Mill, Shitike, Coyote, Quartz, Metolius, lower Deschutes river)	$32,000/yr	$250,000	Large channel reconstruction, lwd, gabion and berm removals, riparian plantings
	Passage improvements road decommissioning	$120,000/yr	$600,000	Replacing or removing culverts for improved passage and capacity
Deschutes River Conservancy	Instream Leasing	$30,000/yr	$150,000	Whychus Creek
	Water Rights Acquisitions	$200,000/yr	$1,000,000	Whychus Creek
	Water Conservation	$900,000/yr	$4,500,000	Whychus Creek
Upper Deschutes Watershed Council	Fish habitat / stream restoration / riparian restoration (private land)	$275,000/yr	$3,250,000	Major projects scheduled on Whychus Creek (4 miles), Lake Creek, and Metolius River
	Screening / passage at diversions	$0/yr	$875,000	Major diversion retrofit projects scheduled.
	Culvert upgrades	$0/yr	$125,000	Several small improvement projects scheduled.

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
PGE	Fish habitat – Whychus Cr	$18,000 – 2006		
	Fish habitat – Metolius R			
	Fish habitat – Lower Deschutes	$120,000 – 2006		
Wasco So. SWCD	Riparian buffers	$15,000/yr	$75,000	Funds are for technical work. USDA Farm Services Agency and OWEB are leveraging the technical dollars under the CREP program.
	Upland conservation (includes irrig. efficiency)	$50,000/yr	$250,000	
ODFW	Fish habitat – planning, coordination, M&E	$15,000/yr	$75,000	Whychus Creek and Metolius River
BLM	Upland and riparian weed treatment	$9,000/yr	$45,000	
	Stream and riparian restoration	$29,000/yr	$150,000	Includes maintenance work on existing projects
Totals - **Westside Deschutes River Population**		$2,014,000/yr	$12,545,000	
Crooked River Population (reintroduction area)				
PGE	Fish habitat – Crooked R	$150,000 in 2006		Funding of projects, including McKay Cr
Deschutes River Conservancy	Instream leasing	$40,000/yr	$200,000	
	Water rights acquisitions	$400,000/yr	$2,000,000	
	Water conservation	$1,000,000/yr	$5,000,000	
Crooked River Watershed Council	Passage and screening		$2,700,000	Lower Crooked River and McKay Creek
	Fish habitat – Crooked River & McKay Creek		$1,400,000	Habitat enhancement – Prineville Valley and Private Lands (McKay Cr)
USFS	Fish habitat – McKay Creek drainage	$50,000/yr	$120,000	McKay and Little McKay fish habitat improvements

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
	Culvert Replacements	$100,000/yr	$375,000	Improvements in passage in the Little McKay and McKay Creeks and tribs.
ODFW	Fish screening and Passage	$200,000/yr	$1,000,000	New construction and O&M
	Fish habitat – planning, coordination, M&E	$15,000/yr	$75,000	
BLM	Upland and riparian weed treatment	$27,000/yr	$110,000	
	Stream and riparian restoration	$22,000/yr	$110,000	Includes maintenance work on existing projects
	Fish Passage		$155,500	Stearns Dam Removal
Totals - **Crooked River Population (reintroduction area)**		$2,004,000/yr	$13,245,500	
Lower John Day River Population (below Dayville)				
Gillian County SWCD	habitat	$33,000/yr	$165,000	OWEB
	Rock Creek project	$28,000/yr		One year
	Weed control	$30,000/yr	$120,000	From Oregon Weed Board
ODFW	Fish Habitat - Lower	$100,000/yr	$500,000	(BPA funded @ $540,000 in 2007 and $440,000 for 2008-2009). The budget is spread out depending on projects within the John Day Subbasin.
	Fish screening and Passage	$450,000/yr	$2,250,000	New construction and O&M – John Day screen shop
Sherman County SWCD	CREP	$400,000/yr	$2,000,000	Depends on program availability, Includes rental payments, installed practices, maintenance, etc.
	Habitat	$30,000/yr	$150,000	Passive restoration projects, i.e. off-stream water, tree planting, and 1 possible channel project
	Upland	$185,000/yr	$925,000	Erosion control structures, pasture fencing, brush control, range reseeding, etc.
CTWSRO	Pine Creek Conservation area	$210,000/yr	$1,750,000	Invasive weed control, CREP implementation, prescribed fire, juniper control
	John Day watershed restoration program	$42,000/yr	$325,000	Riparian plantings, juniper control, off channel water developments.

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
	John Day watershed restoration program	$294,532/yr	$1,500,000	Pushup dam removals, Point of diversion consolidation, return flow coolers,
USFS	Fish Habitat – Rock Creek	$30,000/yr		
	Various projects		$100,000	Ochoco NF
	Culvert Replacements – Various tribs		$375,000	Ochoco NF
Wasco Co. SWCD	Riparian buffers	$15,000/yr	$75,000	Funds are for technical work. USDA Farm Services Agency and OWEB are leveraging the technical dollars under the CREP program.
Wheeler County SWCD	Passage – diversion projects, culverts, bridge	$485,000/yr	$2,425,000	Replacement of push-up dams and other barriers, culvert replacement, fish ladder, screen, Service Creek bridge
	Irrigation efficiency	$390,000/yr	$1,450,000	Converting open ditch to pipelines
	uplands	$99,300/yr	$500,000	Upland development, juniper removal and abatement, spring development
BLM	Upland and riparian weed treatment	$54,000/yr	270,000	
	Stream and riparian restoration	$43,000/yr	$215,000	Includes maintenance work on existing projects
Totals - **Lower John Day River Population (below Dayville)**		$2,918,832/yr	$15,095,000	
North Fork John Day Population				
CTUIR	Fish habitat	$321,000/yr	$1,600,000	(BPA - $249,000; NRCS - $50,000; PCSRF - $22,000)
ODFW	Fish habitat – North Fork drainage	$200,000/yr	$500,000	(BPA funded @ $540,000 in 2007 and $440,000 for 2008-2009). The budget is spread out depending on projects within the John Day Subbasin.
	Fish screening and Passage	$300,000/yr	$1,500,000	New construction and O&M – John Day screen shop
CTWSRO	John Day watershed restoration program	$136000/yr	0	Pushup dam removals/ replacements
Grant SWCD	Fish Habitat – mine tailings, shaping for	$192,000/yr	$960,000	OWEB, Umatilla NF, CTUIT, USFW Service Partners and Acid Spill

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
	Flood Plain, reconnection & habitat diversity – Clear Creek			
North Fork John Day Watershed Council	Fish Habitat	$14,500/yr	$650,000	Levee Removal (future projects include push-up dam removals)
	Uplands	$40,000/yr	$350,000	(off stream watering, spring developments, juniper removal)
	Weed Treatment	$15,000/yr	$125,000	(cost share program and development of a CWMA)
USFS	Culverts and bridge fish passage improvements	$50,000/yr	$150,000	Umatilla and Wallowa-Whitman NFs
	Riparian planting	$10,000/yr	$25000	Partner projects-Umatilla NF
	Road decommissioning-and obliterations	$30,000/yr	$250,000	fire and watershed restoration-Umatilla NF
	Abandoned dredge tailings, redistribution/floodplain restoration	$70,000/yr	$25,000	Umatilla NF/Granite Creek watershed/partner w/Grant SWCD and CTUIR
	Floodplain restoration/wood and revegetation	$0/yr	$25,000	Umatilla NF Partner projects w/ Grant SWCD
	Road maintenance	$30,000/yr	$150,000	Erosion reduction-Umatilla NF
	Instream habitat improvement		$25,000	Partner project w/CTUIR
	Dredge tailing/fish passage restoration	$0/yr	$50,000	Wallowa-Whitman NF/Granite Creek watershed
	Upland revegetation		$400,000	Fire rehab-Umatilla NF
BLM	Upland and riparian weed treatment	$9,000/yr	$45,000	
	Stream and riparian restoration	$7,000/yr	$175,000	Includes maintenance work on existing projects
Totals - **North Fork John Day Population**		$1,424,500/yr	$7,005,000	

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
Middle Fork John Day Population				
ODFW	Fish Habitat - Middle	$100,000/yr	$500,000	(BPA funded @ $540,000 in 2007 and $440,000 for 2008-2009). The budget is spread out depending on projects within the John Day Subbasin.
	Fish screening and Passage	$300,000/yr	$1,500,000	New construction and O&M – John Day screen shop
CTWSRO	Oxbow Conservation area	$139,000/yr	$1,750,000	Invasive weed program, in-channel habitat improvements, CREP
	Forrest Conservation area	$146,000/yr	$367,000	Invasive weed program, in-channel habitat improvements, CREP
	John Day watershed restoration program	$42,000/yr	$330,000	Riparian plantings, juniper control, off channel water developments.
Grant SWCD	Fish passage – irrigation diversions MF and tributaries	$243,835/yr	$1,250,000	BPA, BOR
North Fork John Day Watershed Council	Fish Habitat		$300,000	Culvert replacement
	Uplands	$20,000/yr	$150,000	Off stream watering, juniper removal
	Weed Treatment	$7,000/yr	$50,000	(cost share and development of a CWMA)

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
The Nature Conservancy	Fish habitat		$375,000	
USFS	Riparian planting/revegetation	$10,000/yr	0/yr	Fire rehab.-Umatilla NF
	Noxious weed control	$20,000/yr	$50,000	Umatilla NF
USFS	Riparian revegetation	$28,000/yr	$25,000	Culvert replacement sites-Malheur NF
	Noxious weed control	$50,000/yr	$250,000	Malheur NF
Totals - **Middle Fork John Day Population**		$1,105,835/yr	$6,897,000	
South Fork John Day Population				
ODFW – 2007-Fish Habitat	Fish Habitat - Middle	$30,000/yr	$150,000	(BPA funded @ $540,000 in 2007 and $440,000 for 2008-2009). The budget is spread out depending on projects within the John Day Subbasin.
	Fish screening and Passage	$300,000/yr	$1,500,000	New construction and O&M – John Day screen shop
CTWSRO	John Day watershed restoration program		$0	Pushup dam removals, Point of diversion consolidation, return flow coolers, pump stations
	John Day watershed restoration program	$10000/yr	$50,000	Riparian plantings, juniper control, off channel water developments
USFS	Culvert Replacements – various tribs	$25,000/yr	$150,000	Ochoco NF
USFS	Noxious weed control	$30,000/yr	$150,000	
	Erosion control seeding	$644,000/yr	$50,000	Fire restoration
Grant SWCD	Uplands - Juniper & Weed Control, Riparian Fence, Off-Site Stock Water, Seeding	$177,500/yr	8875,000	USDA National Forest Title II

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
BLM	Upland and riparian weed treatment	$36,000/yr	$180,000	
	Stream and riparian restoration	$29,000/yr	$150,000	Includes maintenance work on existing projects
Totals - **South Fork John Day Population**		$1,281,500/yr	$11,255,000	
Upper John Day River Population				
ODFW – 2007-Fish Habitat	Fish Habitat - Upper	$110,000/yr	$550,000	(BPA funded @ $540,000 in 2007 and $440,000 for 2008-2009). The budget is spread out depending on projects within the John Day Subbasin.
	Fish screening and Passage	$450,000/yr	$2,250,000	New construction and O&M -- John Day screen shop.
CTWSRO	John Day watershed restoration program	$436,000/yr	$2,500,000	Pushup dam removals, Point of diversion consolidation, return flow coolers,
	John Day watershed restoration program	$42,000/yr	$325,000	Riparian plantings, juniper control, off channel water developments.
Grant SWCD	Fish Passage, Diversions & Culverts, Irrigation Return Flow Cooling	$691,390/yr	$3,500,000	BPA, BOR
USFS	Noxious weed control	$50,000/yr	$250,000	
	Grazing management improvement-upland water development	$60,000/yr	0/yr	
	Riparian fence	$25,000/yr	$50,000	
BLM	Upland and riparian weed treatment	$9,000/yr	$45,000	
	Stream and riparian restoration	$7,000/yr	$35,000	Includes maintenance work on existing projects
Totals - **Upper John Day River Population**		$1,880,390/yr	$9,505,000	
Umatilla River Population				
CTUIR	Fish habitat	$548,000/yr	$2,700,000	(BPA - $326,000; PCSRF - $22,000; EPA - $150,000; WHIP - $50,000)
Umatilla Co. Soil	Fertilizer reduction	$150,520/yr	$300,000	OWEB & EPA incentive to use precision Ag technology

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
& Water Conservation District	Weed Control	$103,250/yr	$500,000	OWEB-Promoting use of the WeedSeeker
	Fish passage improvement	$150,000/yr	$750,000	OWEB-ODF&W Improve fish passage on Birch Creek and irrigation efficiency
	Off stream watering facilities	$71,044/yr	$400,000	OWEB- providing upland watering facilities
USFS		$0		USFS is not currently investing in the subbasin with active restoration
ODFW	Fish habitat	$300,000/yr	$1,400,000	BPA funded
	Fish screening and Passage	$100,000/yr	$500,000	New construction and O&M -- John Day screen shop
Totals - **Umatilla River Population**		$1,422,814/yr	$6,550,000	
Walla Walla River Population				
CTUIR	BPA fish habitat	$338,000/yr	$1,700,000	
	BPA ladders/screens	$250,000/yr	$1,250,000	
	other	$22,000/yr	$110,000	
	TOTAL	$610,000/yr	$3,050,000	(BPA - $588,000; PCSRF - $22,000)
Walla Walla WSC	Fish passage	$76,000/yr	$800,000	OWEB, NRCS –push up dam replacements
	Flow improvement	$157,000/yr	$1,200,000	OWEB, BPA, NRCS – irrigation efficiencies/ conserved water transferred to instream water right
	Habitat/ levee setback	$89,000/yr	$250,000	OWEB - moving corral off creek bank, setting back private levee
	Pesticide use reduction	$20,000/yr	$60,000	ODEQ – assisting growers in reducing the amount of pesticides reaching streams
Umatilla Co. Soil & Water Conservation District	Animal (cattle) Relocation	$62,142/yr		OWEB- moving cattle off creek riparian area to an upland

Table I-2
Current Average Expenditures on Habitat Projects for Mid-Columbia River Steelhead

Agency or Organization	Program	Recent average annual expenditures or budget	Expected next five year expenditures	Comments
USFS		$0		USFS is not currently investing in the subbasin with active restoration
WWBWC	Habitat restoration	$48,000/yr	$240,000	Funded by OWEB
ODFW John Day screen shop	Fish screening and Passage	$100,000/yr	$500,000	New construction and O&M
Totals - **Walla Walla River Population**		$1,772,142/yr	$9,160,000	

APPENDIX J

U.S. Forest Service Briefing Paper

Fuels Treatment as an Action Contributing to Recovery of ESA-listed Anadromous Salmonids

Forest Service Briefing Paper

Subject Fuels treatment as an action contributing to recovery of ESA-listed anadromous salmonids

Key Messages

- Science-based assessments of the Columbia and Snake River basins have documented that both forest and aquatic ecosystems have undergone important changes from historical conditions.
    - Forests structure, composition, and patterns have been significantly altered, resulting in a higher risk of stand replacement fires.
    - Watersheds have been degraded, threatening the stability and persistence of native fishes -- including ESA-listed salmon and steelhead stocks.
- Growing public recognition of degraded forest and aquatic ecosystem condition has resulted in policy and scientific debate over whether fuels treatments provide benefits to ESA-listed salmonid populations, or conversely, represent a risk of further degradation in watershed conditions on which they depend.
- Context matters – any evaluation of trade-offs (benefits and risks) to ESA-listed salmonids from fuels treatments will be dependent on local conditions and successful integration of objectives.
- Three primary elements must be integrated to meet both forest and aquatic system restoration objectives:
    - Conservation of key remnant aquatic and forested habitats with their associated native fish and wildlife populations, to serve as 'building blocks' for the future;
    - Restoration of degraded watersheds (both forest and aquatic conditions); and
    - Restoration of more natural patterns of forest habitat, including patterns of dead and down trees to reduce the landscape risk of large and damaging wildfires.
- A multi-scale analysis –assessments at both the recovery domain and watershed scales--- is clearly an important process to evaluate tradeoffs between the benefits and risks of fuels treatment activities and assess their value in support of recovery of ESA-listed salmonids. Such analyses provide a framework and necessary geographic context and specificity to evaluate fuels treatments based on each recovery domain and watershed's unique bio-physical characteristics.

Reiman et al. (2000) provide a critical "first step" or "coarse filter" analytical framework to assist managers, policy-makers, and technicians in evaluating these trade-offs (benefits/risks). Based on their integrated analysis of terrestrial and aquatic ecosystems in the Interior Columbia River Basin, each subbasin was assigned a general 'theme' and specific management recommendations are outlined regarding opportunities for fuels treatment actions and other restorative actions to maintain and restore the integrity of watershed and aquatic systems (Figure 1). Additional, finer-scale watershed analyses will often be necessary to refine this approach in order to: 1) recognize commonality in management goals, opportunities, and conflicts; and 2)

identify specific, integrated actions needed to support ESA-listed fishes. An example of such an analysis is displayed in Figures 2 and 3.

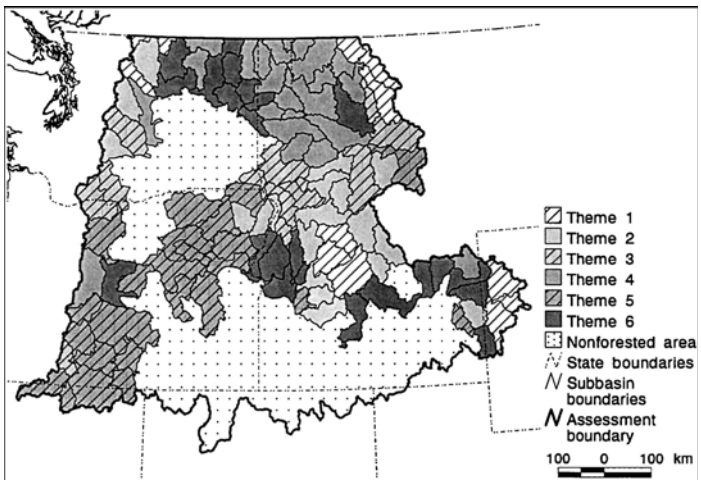


Figure 1 (from Rieman et al. 2000)

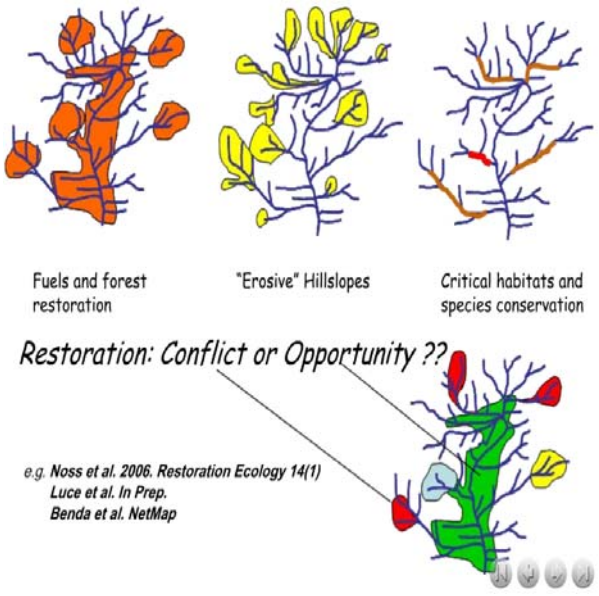


Figure 2 (from Rieman et al. 2007)

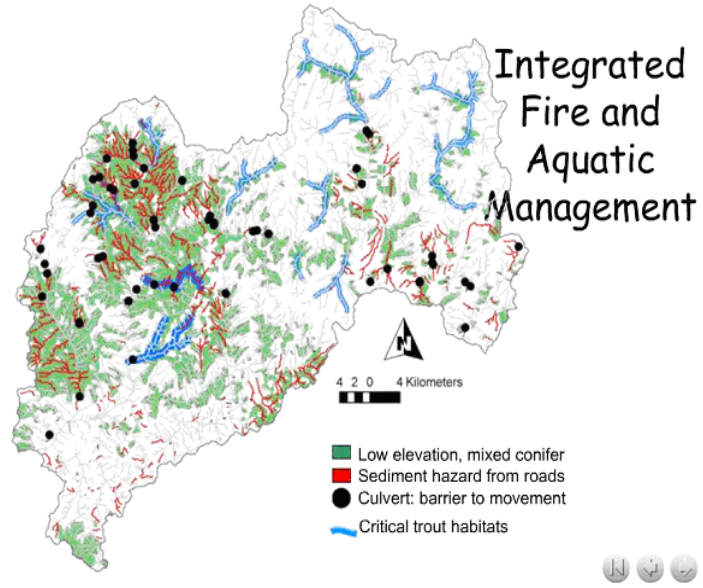


Figure 3 (from Rieman et al. 2007)

Where management objectives and conditions in forested and aquatic systems are in conflict, significant care and investment in analysis and management activities may be required. Placing subbasins into the appropriate theme, as described above, should be considered as an important first step in the prioritization of management resources expended in recovery. By focusing intensive restoration initially in areas of greatest potential ecological benefit and least risk, the skills and opportunity to move into more sensitive areas will likely emerge.

This paper was summarized and sections excerpted from the Rieman et al. (2000) publication by L. Ulmer, B. Staab, D. Shively, and S. Woltering; USDA, Forest Service, Portland, Oregon.

References:
Rieman, B.E., D.C. Lee, R.F. Thurow, P.F. Hessburg, and J.R.Sedell. 2000. Toward an Integrated Classification of Ecosystems: Defining Opportunities for Managing Fish and Forest Health. Environmental Management Vol. 25, No. 4, pp. 425-444.

Reiman, B, C. Luce, J. Dunham, A. Rosenberger, J. Buffington, M. Dare, H. Neville, P. Hessburg, A. Black, and C. Miller. 2007. Wildfire and Fish: Implications for Management. Presentation. USFS Watershed Seminar Series.

Attachment A: Themes from Rieman (2000)

Theme 1: Wild and Minimally Roaded, Cold and Moist Forests – exhibit the least departure from historical conditions in either forest or aquatic ecosystems (roadless, wilderness) and provide the best opportunity to conserve elements of ecosystems most resembling natural or historical conditions

Management Implications

- Due to low departure from historical conditions (forested & aquatic), active restoration is a low priority relative to subbasins under other 'themes'
- Primary management opportunity is to conserve existing conditions
- Both managed and natural ignitions can play an important role in restoring forests

Theme 2: Semi-Wild and Moderately-Roaded Areas – represent forest and aquatic conditions varying from fair to relatively healthy (blocks of wilderness, roadless)

Management Implications

- Conserve existing integrity of high-elevation and headwater areas
- Actively restore more productive and lower risk conditions in middle and lower montane settings

Theme 3: Mixed and Opposing Conditions – conditions in forest and aquatic ecosystems are not consistent. Forests within these subbasins have the highest departure in mean fire frequency and severity. Although aquatic systems are rated as favorable, in contrast to forested areas, strong salmonid populations are found in only an average number of subbasins but most fish communities are still dominated by native species.

Management Implications

- Maintaining and improving the productivity of aquatic ecosystems and restoring forests will likely require active management.
- Although there may be opportunities to restore aquatic and forest conditions simultaneously, it may necessitate trade-offs. Aquatic systems within this theme are generally in good condition but overlap with poor forest conditions. Emphasis of forest treatments may pose unacceptable risks to watershed objectives
- Potential conflict between management objectives support the need for more
- detailed risk analysis (watershed scale)

Theme 4: Mixed Conditions, Moist Forests – subbasins in this class exhibit moderate to high levels of departure from historical conditions in both forest and aquatic systems due to extensive land management and high road densities. The need for restoration in both systems, and the productive nature of the forests, implies both risks and opportunities for management.

Management Implications

- There is a need to restore both.
- As there are productive forests, and areas of both productive aquatic habitat and intact fish communities, these subbasins may be priorities for investments in restoration.
- Due to the extensive and, potentially surplus road networks, opportunities for active forest restoration is high. Removal of roads after forest restoration work is completed could lead to improved watershed conditions where sediment and fragmentation is limiting recovery.
- The presence of large areas of moist forest types within this theme expands management opportunities. Historically, mixed and lethal fire regimes were dominant suggesting large and intense disturbance events with long recovery periods
- Recommend focused and intense restoration actions over short time periods (5-10 years) with longer time periods for recovery (30-50 years). This restoration strategy may minimize the need for extensive and permanent road networks and enable large-scale restoration with less funding.

Theme 5: Mixed Condition, Dry Forest – both forest and aquatic systems are similar to subbasins under Theme 4 (departure from historical conditions, high road densities, extensive land management) but dry forest types are dominant. Theme 5 differs from Theme 4 in that forests are less productive, historical fire regimes were primary non-lethal and mixed and had frequent fire return intervals.

Management Implications

- Restoration needs similar to those recommended under Theme 4 but active restoration will require more frequent entry and a higher level of maintenance for a more extensive road network.
- Economic benefits from logging (dry forest types) are lower than under Theme 4 and probably will not support low-impact operations (e.g., helicopter logging) as often as in more productive moist forest types. This will in turn require that existing road networks remain in place, long-term to derive any economic benefit.
- Although the same opportunities for aquatic habitat restoration are found as under Theme 4 (removal of unnecessary roads), forest restoration should make use of existing roads, rather than construct new ones, and attempt to eliminate roads limiting watershed integrity.

Theme 6: Poor Conditions – both forest and aquatic systems are in poor condition. For aquatic systems, they are in a degraded condition with remaining populations of native fishes often isolated and fragmented. Fragmentation of habitat is most common in lower elevation lands adjoining forested areas. For forest systems, the composition and degree of departure from historical conditions is similar to Theme 5. In contrast, subbasins under Theme 6 comprise a more diverse mix of dry and moist forest conditions with fire frequency changes also not as pronounced. Road densities are also lower than under Theme 4 or 5.

Management Implications

- Limited opportunity for restoration of functional aquatic networks
- Conserve remnant habitats of native fishes and maintain high water quality
- Forest restoration activities would present low risk to remaining critical habitat providing these are sited appropriately

Recovery Plan
for the Klickitat River Population of the Middle Columbia River Steelhead Distinct Population Segment

September 2009

Prepared by
National Marine Fisheries Service
Northwest Region

DISCLAIMER

Endangered Species Act (ESA) recovery plans delineate reasonable actions which the best available information indicates are necessary for the conservation and survival of listed species. Plans are published by the National Marine Fisheries Service (NMFS), usually with the assistance of recovery teams, state agencies, local governments, salmon recovery boards, non-governmental organizations, interested citizens of the affected area, contractors, and others. ESA recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than NMFS. They represent the official position of NMFS only after they have been signed by the Northwest Regional Administrator. ESA recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions.

With respect to the Middle Columbia Steelhead Recovery Plan, where areas of disagreement arose between a management unit plan and the species level, distinct population segment (DPS) plan, NMFS worked with the relevant parties to resolve the differences and in a few cases, identified in the DPS plan, decided not to incorporate the disputed material into the DPS plan.

ESA recovery plans provide important context for NMFS's determinations pursuant to section 7(a)(2) of the Endangered Species Act. However, recovery plans do not place any additional legal burden on NMFS or the action agency when determining whether an action would jeopardize the continued existence of a listed species or adversely modify critical habitat. The procedures for the section 7 consultation process are described in 50 CFR 402 and are applicable regardless of whether or not the actions are described in a recovery plan.

Contents

Acronyms ..... **xiv**

Executive Summary ..... **xvi**

Purpose of Plan xvi
Context of Plan Development xvii
Biological Background xviii
Recovery Goals and Criteria xxi
Threats Criteria and Approach xxii
Current Status Assessment xxiii
Limiting Factors and Threats xxiii
Recovery Strategy and Actions xxv
Cost Estimates xxviii
Implementation xxix
Research, Monitoring, and Adaptive Management xxx

1. Introduction **1**

1.1 Purpose of Plan 2
1.1.1 ESA Requirements 3
1.1.2 Coordination with Others 3
1.2 Context of Plan Development 5
1.2.1 Technical Recovery Teams 6
1.2.2 Planning Forums 6
1.3 How NMFS Intends to Use the Plan 8

2. Biological Background **9**

2.1 Populations and Major Population Groups 9
2.2 Physical Setting 9
2.3 Ecosystem Conditions 12
2.3.1 Hydrology 12
2.3.2 Water Quality 14
2.3.3 Riparian Function and Condition 15
2.3.4 Migration Barriers 15
2.4 Life History Characteristics 17

3. Recovery Goals and Viability Criteria **26**

3.1 Recovery Goals 26
3.2 Biological Viability Criteria 27
3.2.1 DPS and MPG Viability Criteria 27
3.2.2 Application of Biological Viability Criteria to Klickitat Population 28
3.3 Threats Criteria 29

4. Current Status Assessment **33**

4.1 ICTRT Status Assessment 33
4.1.1 Major and Minor Spawning Areas 33
4.1.2 Abundance and Productivity 35
4.1.3 Spatial Structure and Diversity 36
4.1.4 Overall Risk Rating 40

5. Limiting Factors and Threats **42**

5.1 Hatchery Effects 42
5.2. Freshwater Habitat 45
5.2.1 Major Spawning Areas 46

5.2.2 Minor Spawning Areas 53
5.3 Tributary Harvest 55
5.4 Out-of-Subbasin Limiting Factors and Threats 58
5.4.1 Harvest 59
5.4.2 Columbia River Hydro Operations 60
5.4.3 Ocean Conditions 61
5.4.4 Climate Change 61
5.4.5 Other Large-Scale Threats 62
6. Recovery Strategy and Actions 63
6.1 Strategies and Actions to Address Data Gaps 64
6.2 Hatchery-Related Strategies and Actions 67
6.3 Freshwater Habitat Strategies and Actions 69
6.4 Harvest-Related Strategies and Actions 78
6.5 Mainstem Columbia Hydrosystem and Estuary -- Strategies and Actions 79
6.6 Potential Effects of Proposed Recovery Actions 80
7. Implementation and Preliminary Cost Estimates 83
7.1 Implementation 83
7.2 Preliminary Cost Estimates 84
8. Monitoring, Research, and Adaptive Management 95
8.1 Adaptive Management 95
8.2 Designing a Monitoring and Evaluation Program to Support Adaptive Management 98
8.3 Existing Monitoring and Research 99
8.3.1 Status and Trends Monitoring 100
8.3.2 Effectiveness Monitoring 101
8.3.3 Critical Uncertainty Research 101
8.4 Additional Needs 101
8.5 Data Management 109
8.6 Consistency with Other Monitoring Programs 110
8.7 Coordination 110
8.8 Evaluation Schedule 110
9. References 111
Appendix I. Major Creek 120
1 Physical Setting 120
2 Ecosystem Conditions 120
3 Current Status 122
4 Potential Limiting Factors and Threats 123
5 Management Actions 123
6 Cost Estimates 124
Appendix II. Potential Limiting Factors and Threats Identified by Yakama Nation Fisheries 125
Appendix III. Current Efforts and Regulations 147
Appendix IV. Estimates of Abundance Provided by Yakama Nation Fisheries 163

Tables

Table ES-1.....Recovery Strategies and Actions for the Klickitat River Steelhead Population xxxii
Table 4-1 .....Klickitat Summer/Winter Steelhead Basin Statistics.....38
Table 4-2 .....ICTRT viability assessment results for Klickitat steelhead population spatial structure and diversity factors and metrics 39
Table 4-3 .....Spatial Structure and Diversity Scoring Table: Klickitat Steelhead Population 40
Table 5-1 .....Results of red surveys completed by Yakama Nation Fisheries in the Klickitat basin, 2002 – 2007 44
Table 5-2 .....Fine sediment concentrations in gravels in the Major and Minor Spawning Areas in the Klickitat basin.....47
Table 5-3 .....Maximum Recorded Temperature 47
Table 5-4 .....Summary of water temperature data collected in the tributaries included in the Lower Mainstem Major Spawning Area.....51
Table 5-5 .....Estimated Harvest for Klickitat River Steelhead, 1986-2007.....57
Table 6-1 .....Strategy 1: Protect Stream Corridor Structure and Function 74
Table 6-2 .....Strategy 2: Restore Passage and Connectivity.....74
Table 6-3 .....Strategy 3: Restore Floodplain Function and Channel Migration 75
Table 6-4 .....Strategy 4: Restore Riparian Condition 76
Table 6-5 .....Strategy 5: Restore Altered Hydrographs 76
Table 6-6 .....Strategy 6: Restore Degraded Water Quality.....77
Table 6-7 .....Estimated Productivity and Abundance of Klickitat River Steelhead Associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions 82
Table 7-1 .....Klickitat Subbasin Capital Construction Costs.....85
Table 7-2 .....Habitat Actions and Costs for Klickitat Steelhead 86
Table 8-1 .....Summary of ongoing and expanded M&E cost estimates 109
Table I-1.....Needed Actions, Estimated Time to Implement and Cost Assessment of Wild Major Creek Steelhead.....124
Table II-1 .....Correlations between ICTRT and Yakama Nation Fisheries 128
Table II-2 .....EDT Strategic Priority Summary for Protection and Restoration of Klickitat Steelhead 129
Table II-3 .....Limiting Factors for Middle Columbia River Steelhead in Upper Mainstem MaSA 130
Table II-4 .....Limiting Factors for Middle Columbia River Steelhead In White Creek MaSA 132

Table II-5 .....Limiting Factors for Middle Columbia River Steelhead in Middle Mainstem MaSA 134
Table II-6 .....Potential Limiting Factors for Middle Columbia River Steelhead in the Lower Mainstem MaSA.....136
Table II-7 .....Limiting Factors for Middle Columbia River Steelhead in the Upper Little Klickitat MaSA 138
Table II-8 .....Potential Limiting Factors for Middle Columbia River Steelhead in the West Fork Klickitat MaSA 141
Table II-9 .....Potential Limiting Factors for Middle Columbia River Steelhead in the Swale Creek MiSA 143
Table II-10 ....Potential Limiting Factors for Middle Columbia River Steelhead in the Surveyor's Creek MiSA.....143
Table II-11 ....Potential Limiting factors for Middle Columbia River Steelhead in Lower Little Klickitat MiSA 143
Table II-12 ....Potential Limiting Factors for Middle Columbia River Steelhead in the Trout Creek MiSA 145
Table III-1.....Trust Forest and Non-Forest Areas by Management Emphasis 160
Table IV-1.....Estimated Klickitat River Steelhead Returns, Harvest and Escapement .161

Figures

Figure ES-1...Klickitat Subbasin..... xvii
Figure ES-2...Independent Populations in the Mid-Columbia River DPS..... xix
Figure ES-3...Major Population Groups of Mid-Columbia Steelhead.....xx
Figure 1-1.....Klickitat Subbasin.....1
Figure 1-2.....Management Units for Mid-Columbia River Steelhead DPS 7
Figure 2-1.....Independent Populations in the Mid-Columbia River Steelhead 10
Figure 2-2.....Major Population Groups of Mid-Columbia Steelhead.....11
Figure 2-3.....Klickitat Subbasin Land Ownership, Towns and Stream Locations 12
Figure 2-4.....Mean Monthly Stream Flow for Six USGS-Operated Gauges on the Little Klickitat and Mainstem Klickitat rivers 13
Figure 2-5.....Average Ocean Age Composition of Wild Summer Steelhead in the Klickitat River 20
Figure 2-6.....Frequency Distribution of Fork Length at Ocean Age of Wild Summer Steelhead in the Klickitat River 20
Figure 2-7.....Average Ocean Age Composition Klickitat Winter-run Steelhead 21
Figure 2-8.....Frequency Distribution of Fork Length at Ocean Age of Wild Winter Steelhead in the Klickitat River, 2004-2005.....21
Figure 4-1.....Klickitat River Steelhead Population Boundary and Historical Major and Minor Spawning Areas 35

Figure 4-2.....Summer and Winter Steelhead Distribution in the Klickitat Subbasin.....37
Figure 4-3.....Percentage of Historical Spawning Habitat by Major/Minor Spawning Area 38
Figure 4-4.....Viable Salmonid Population Parameter Risk Ratings for the Klickitat River Steelhead Salmon Population 41
Figure 6-1.....EDT Relative Importance of Major and Minor Spawning Areas for Protection and Restoration Measures for Klickitat Steelhead 72
Figure 8-1.....NMFS Listing Status Decision Framework.....97
Figure I-1 .....Map of the Major Creek Subbasin in Southern Washington showing Steelhead Distribution.....121

Recovery Planning Glossary

abundance: In the context of salmon recovery, unless otherwise qualified, abundance refers to the number of adult fish returning to spawn.

adaptive management: Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.

anadromous fish: Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.

baseline monitoring: In the context of recovery planning, baseline monitoring is done before implementation, in order to establish historical and/or current conditions against which progress (or lack of progress) can be measured.

biogeographical region: an area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms (in this case, salmonids) have evolved in common.

broad-sense recovery goals: Goals defined in the recovery planning process, generally by local recovery planning groups, that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values.

compliance monitoring: Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.

delisting criteria: Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a NMFS determination and may include both technical and policy considerations.

distinct population segment (DPS): A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NMFS policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.

diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in

freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.

endangered species: A species in danger of extinction throughout all or a significant portion of its range.

effectiveness monitoring: Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?

ESA recovery plan: A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.

evolutionarily significant unit (ESU): A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species.

extinct: No longer in existence. No individuals of this species can be found.

extirpated: Locally extinct. Other populations of this species exist elsewhere. The ICTRT considers extirpated steelhead populations to be those that are entirely cut off from anadromy, such as the Crooked River population. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

factors for decline: Five general categories of causes for decline of a species, listed in the Endangered Species Act section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.

functionally extirpated: Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population.

hyporheic zone: Area of saturated gravel and other sediment beneath and beside streams and rivers where groundwater and surface water mix.

implementation monitoring: Monitoring to determine whether an activity was performed and/or completed as planned.

independent population: Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.

indicator: A variable used to forecast the value or change in the value of another variable.

interim regional recovery plan: A recovery plan that is intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.

intrinsic potential: The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

intrinsic productivity: The expected ratio of natural-origin offspring to parent spawners at levels of abundance below carrying capacity.

iteroparous: Capable of reproducing more than once in a lifetime.

kelts: Steelhead that are returning to the ocean after spawning and have the potential to spawn again in subsequent years (unlike most salmon, steelhead do not necessarily die shortly after spawning).

large woody debris (LWD): A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.

legacy effects: Impacts from past activities that continue to affect a stream or watershed in the present day.

limiting factor: Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status.

locally developed recovery plan: A plan developed by state, tribal, regional, or local planning entities to address recovery of a species. These plans are being developed by a number of entities throughout the region to address ESA as well as state, tribal, and local mandates and recovery needs.

maintained status: Population status in which the population does not meet the criteria for a viable population but does support ecological functions and preserve options for ESU/DPS recovery.

major population group (MPG): A group of salmonid populations that are geographically and genetically cohesive. The MPG is a level of organization between demographically independent populations and the ESU or DPS.

major spawning area (MaSA): A system of one or more branches that contain sufficient spawning and rearing habitat to support more than 500 spawners. For Interior Columbia salmonid populations: defined using results from intrinsic potential analysis.

management unit: A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.

metrics: A metric is something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.

minor spawning area (MiSA): A system of one or more branches that contain sufficient spawning and rearing habitat to support 50-500 spawners. For Interior Columbia salmonid populations: defined using results from intrinsic potential analysis.

morphology: The form and structure of an organism, with special emphasis on external features.

natural-origin fish: Fish that were spawned and reared in the wild, regardless of parental origin.

parr: The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.

phenotype: Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties, or behavior.

piscivorous: (Adj.) Describes fish that eat other fish.

productivity: The average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

recovery domain: An administrative unit for recovery planning defined by NMFS based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.

recovery goals: Goals incorporated into a locally developed recovery plan, which may include delisting (i.e. no longer considered endangered or threatened), reclassification

(e.g., from endangered to threatened), and/or other goals. Broad-sense goals are a subset of recovery goals (see glossary entry above).

recovery plan supplement: A NMFS supplement to a locally developed recovery plan that describes how the plan addresses ESA requirements for recovery plans. The supplement also proposes ESA delisting criteria for the ESUs addressed by the plan, since a determination of these criteria is a NMFS decision.

recovery scenarios: Scenarios that describe a target status for each population within an ESU, generally consistent with TRT recommendations for ESU viability.

redd: A nest constructed by female salmonids in streambed gravels where eggs are fertilized and deposited.
recovery strategy: Statements that identify the assumptions and logic – the rationale – for the species' recovery program.

riparian area: Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland.

salmonid: Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.

smolt: A juvenile salmonid that is undergoing physiological and behavioral changes to adapt from freshwater to saltwater as it migrates toward the ocean.

spatial structure: Characteristics of a fish population's geographic distribution. Current spatial structure depends upon the presence of fish, not merely the potential for fish to occupy an area.

stakeholders: Agencies, groups, or private citizens with an interest in recovery planning, or who will be affected by recovery planning and actions.

Technical Recovery Team (TRT): Teams convened by NMFS to develop technical products related to recovery planning. TRTs are complemented by planning forums unique to specific states, tribes, or regions, which use TRT and other technical products to identify recovery actions.

threatened species: A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

threats: Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

viability criteria: Criteria defined by NMFS-appointed Technical Recovery Teams to describe a viable salmonid population, based on the biological parameters of abundance, productivity, spatial structure, and diversity. These criteria are used as technical input

into the recovery planning process and provide a technical foundation for development of biological delisting criteria.

viability curve: A curve describing combinations of abundance and productivity that yield a particular risk of extinction at a given level of variation over a specified time frame.

viable salmonid population (VSP): an independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame.

VSP parameters: Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, *Viable salmonid populations and the recovery of evolutionarily significant units* (McElhany et al. 2000).

Acronyms

A/P	abundance/productivity
BIA	Bureau of Indian Affairs
BPA	Bonneville Power Administration
CAO	Critical Areas Ordinance
CCRP	Continuous Conservation Reserve Program
CEO	County Environmental Ordinance
CFEF	Castile Falls Enumeration Facility
CFS	cubic feet/second
CKCD	Central Klickitat Conservation District
CREP	Conservation Reserve Enhancement Program
CRITFC	Columbia River Inter-Tribal Fish Commission
CRFMP	Columbia River Fisheries Management Plan
CSMEP	Collaborative Systemwide Monitoring and Evaluation Project
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
CUP	Conditional Use Permits
CZO	County Zoning Ordinance
DO	dissolved oxygen
DOC	Department of Commerce
DPS	distinct population segment
EA	Environmental Assessment
Ecology	Department of Ecology
EDF	energy dissipation factor
EDT	Ecosystem Diagnosis and Treatment
EIS	Environmental Impact Statement
EKCD	Eastern Klickitat Conservation District
EPA	Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESHB	Engrossed Substitute House Bill
ESU	evolutionarily significant unit
FCRPS	Federal Columbia River Power System
FEIS	final environmental impact statement
FMEP	Fisheries Management and Evaluation Plan
FMP	Forest Management Plan
FPO	Floodplain Management Ordinance
FSA	Farm Service Agency
FY	fiscal year
GIS	Geographic Information Systems
GPS	Global Positioning System
HGMP	Hatchery and Genetic Management Plans
HOF	hatchery-origin fish
HSRG	Hatchery Scientific Review Group
HUC	hydrologic unit code
ICTRT	Interior Columbia Technical Recovery Team
ISG	Independent Scientific Group
KMP	Klickitat Anadromous Fishery Master Plan
KWEP	Klickitat Watershed Enhancement Project
KPUD	Klickitat Public Utility District
LCFRB	Lower Columbia Fish Recovery Board

LUMA	Land Use Management Area
MaSA	major spawning area
MCR	Middle Columbia River
MEA	Management Emphasis Area
MiSA	minor spawning area
MPG	major population group
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOF	natural-origin fish
NPCC	Northwest Power and Conservation Council
NPDES	National Pollutant Discharge Elimination System
NSA	National Scenic Area
NWR	National Wildlife Refuge
ODFW	Oregon Department of Fish and Wildlife
OFM	Office of Financial Management
PCSRF	Pacific Coastal Salmon Recovery Fund
PFC	Proper Functioning Condition
PIT	Passive Integrated Transponders
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
RCW	Revised Code of Washington
RM	river mile
RM&E	research, monitoring and evaluation
SDP	Substantial Development Permits
SEPA	State Environmental Policy Act
SMP	Shorelines Master Plan
SR	State Route
SRFB	Salmon Recovery Funding Board
SSB	Substitute Senate Bill
TFW	Timber, Fish, and Wildlife
TMDL	total maximum daily loads
TRT	Technical Recovery Team
USACE	U.S. Army Corps of Engineers
USBOR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VSP	viable salmonid population
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WPN	Washington Permit Notification
WRIA	Water Resource Inventory Area
WSDA	Washington State Department of Agriculture
WDOE	Washington State Department of Ecology
WDOT	Washington State Department of Transportation
WRPAC	Water Resources Planning Advisory Committee
YKFP	Yakima/Klickitat Fisheries Project
YN	Yakama Nation

Executive Summary

The Endangered Species Act of 1973 (ESA) requires NOAA's National Marine Fisheries Service (NMFS) to develop recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA.

This plan focuses on the conservation and survival of Middle Columbia River steelhead (*Oncorhynchus mykiss*) in the Klickitat River subbasin (Figure ES-1).[1] It is one of several recovery plans developed for independent populations of the Middle Columbia River steelhead distinct population segment (DPS), which was listed as threatened under the ESA on March 25, 1999 and reconfirmed on January 5, 2006 (NMFS 2006a, 71 FR 834). Similar plans have been prepared for Middle Columbia steelhead populations in the White Salmon River, Rock Creek, and Yakima River, as well as in areas of southeast Washington and the State of Oregon. These separate plans are part of a DPS-level plan that integrates recovery actions across the DPS.

The Klickitat River population is of particular interest because it contains both summer and winter runs, and it potentially could make a significant contribution to recovery of the Middle Columbia steelhead DPS. The Klickitat River is one of the largest salmon producing watersheds in the Columbia basin. Recent passage improvements at Castile Falls in the upper Klickitat have opened an additional 56 miles of high quality steelhead habitat. Passage improvements in the lower Klickitat (Lyle Falls at RM 2.2) are also expected to benefit immigrating adults. In addition, a hatchery master plan under development by the Yakama Nation in consultation with NMFS is expected to improve hatchery management to support conservation of the naturally spawning steelhead (Sharp et al. 2008). Moving existing *U.S. v. Oregon* production of fall Chinook and coho from the Klickitat hatchery to the new Wahkiacus Acclimation Facility 26 miles downstream will minimize the impacts of large-scale hatchery releases on wild spring Chinook and steelhead rearing between the two facilities.

Purpose of Plan

The plan provides a roadmap for restoring the Klickitat steelhead population and its habitats to a level that supports recovery of the Middle Columbia River steelhead DPS and allows the population to become a viable component of its ecosystem. A recovery plan is a guidance document, not regulatory.

The plan describes the current status of the Klickitat population, identifies the factors and threats affecting the population, and proposes strategies and actions designed to aid in the population's recovery and build on past and current recovery efforts. Finally, the plan

[1] A description of the Major Creek watershed is included as Appendix I of this plan. Major Creek flows into the Columbia River immediately downstream of the Klickitat River and is believed to contain Middle Columbia steelhead. The Interior Columbia Technical Recovery Team has not evaluated the data for Major Creek, but because of its proximity to the Klickitat River, its steelhead may have genetic characteristics similar to the Klickitat steelhead population.

provides an implementation schedule and adaptive management framework for making needed future adjustments on the road to recovery.

Context of Plan Development

The plan is the product of a process initiated by NMFS; it incorporates information from the Yakama Nation (YN), Washington Department of Fish and Wildlife (WDFW), Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal agencies, state agencies, local governments, and the public.

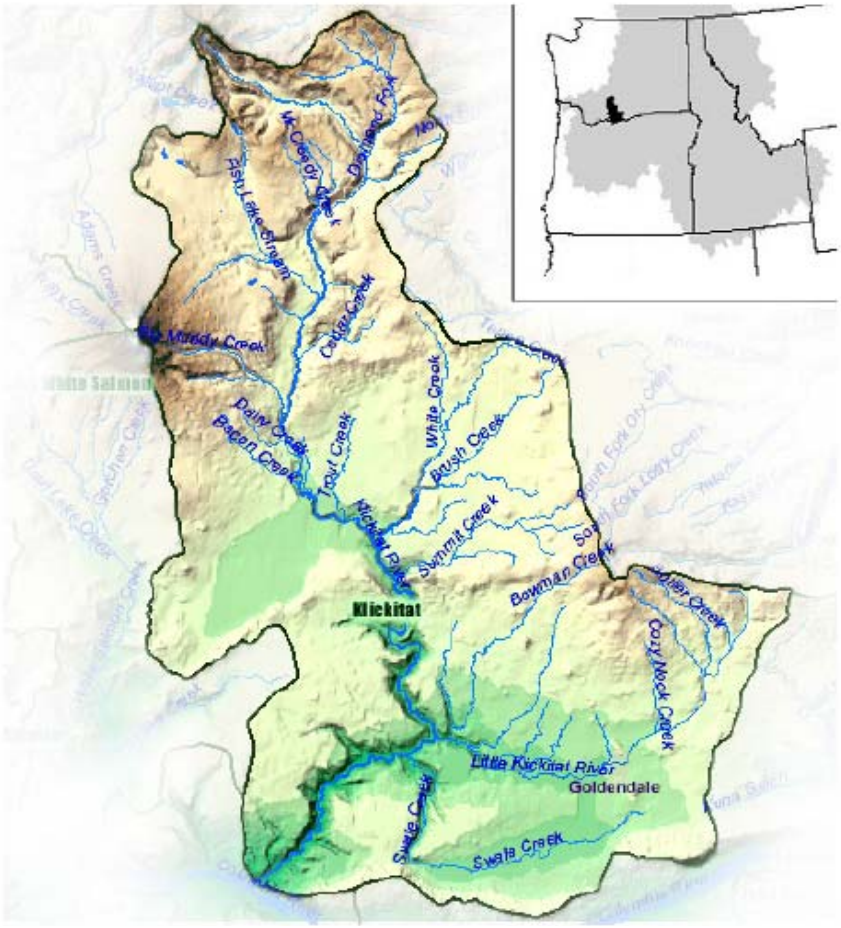


Figure ES-1. Klickitat Subbasin.

The Klickitat Plan reflects direction for Klickitat steelhead adopted into the Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program subbasin plan (NPCC 2004). The subbasin plan was produced through a collaborative process involving the Yakama Nation, Washington Department of Fish and Wildlife, and NPCC.

In addition, the plan reflects technical data drawn from:

- Watershed Resource Inventory Area (WRIA) 30 watershed assessment (WPN and Aspect 2005a) and watershed management plan (WPN and Aspect 2005b)
- The Interior Columbia Technical Recovery Team (ICTRT) viability criteria for the Middle Columbia River steelhead DPS (ICTRT 2007)

Biological Background

The Klickitat River drains approximately 1,350 square miles in south central Washington before joining the Columbia River at Lyle, Washington (RM 180.4), 34 miles upstream of Bonneville Dam. The Klickitat is one of the longest undammed rivers in the Northwest.

Reasons for listing the Middle Columbia River steelhead DPS as threatened under the ESA included low returns to the Yakima River, poor abundance estimates for Klickitat River and Fifteenmile Creek steelhead, uncertainty regarding the influence of hatchery releases on the natural steelhead population, and an overall decline of naturally producing "stocks" within the DPS (64 FR 14517). The Klickitat River population is of particular interest because of containing both summer and winter runs.

The ICTRT identified 17 extant and 3 extirpated independent steelhead populations in the Middle Columbia River steelhead DPS (McClure et al. 2003). These populations are shown in Figure ES-2. The ICTRT delineated the populations based on genetic information, geography, life history traits, morphological traits, and population dynamics.

The ICTRT grouped these independent populations into four major population groups (MPGs) within the DPS: the Cascades Eastern Slope Tributaries MPG, Yakima subbasin MPG, John Day River MPG, and Umatilla/Walla Walla MPG. The Klickitat River population is one of the five extant populations (Klickitat River, Fifteenmile Creek, Rock Creek, Deschutes Eastside, and Deschutes Westside) and two extirpated populations (White Salmon River and Deschutes Crooked River) comprising the Cascades Eastern Slope Tributaries MPG (Figure ES-3). Populations in the group are united primarily by proximity and occupy diverse habitats, generally those draining the eastern slopes of the Cascades and the Columbia Plateau.

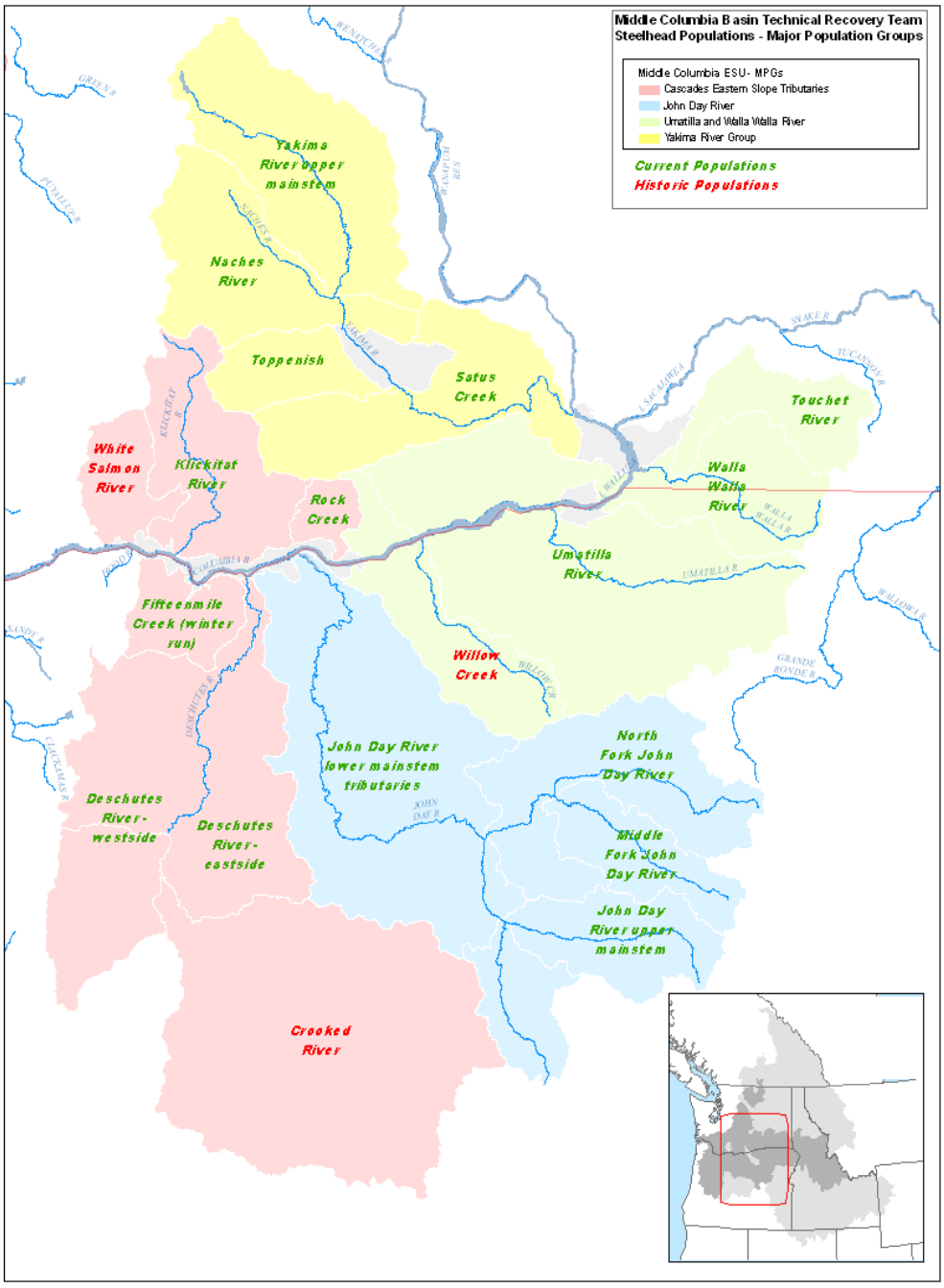


Figure ES-2. Independent Populations in the Middle Columbia River Steelhead DPS.

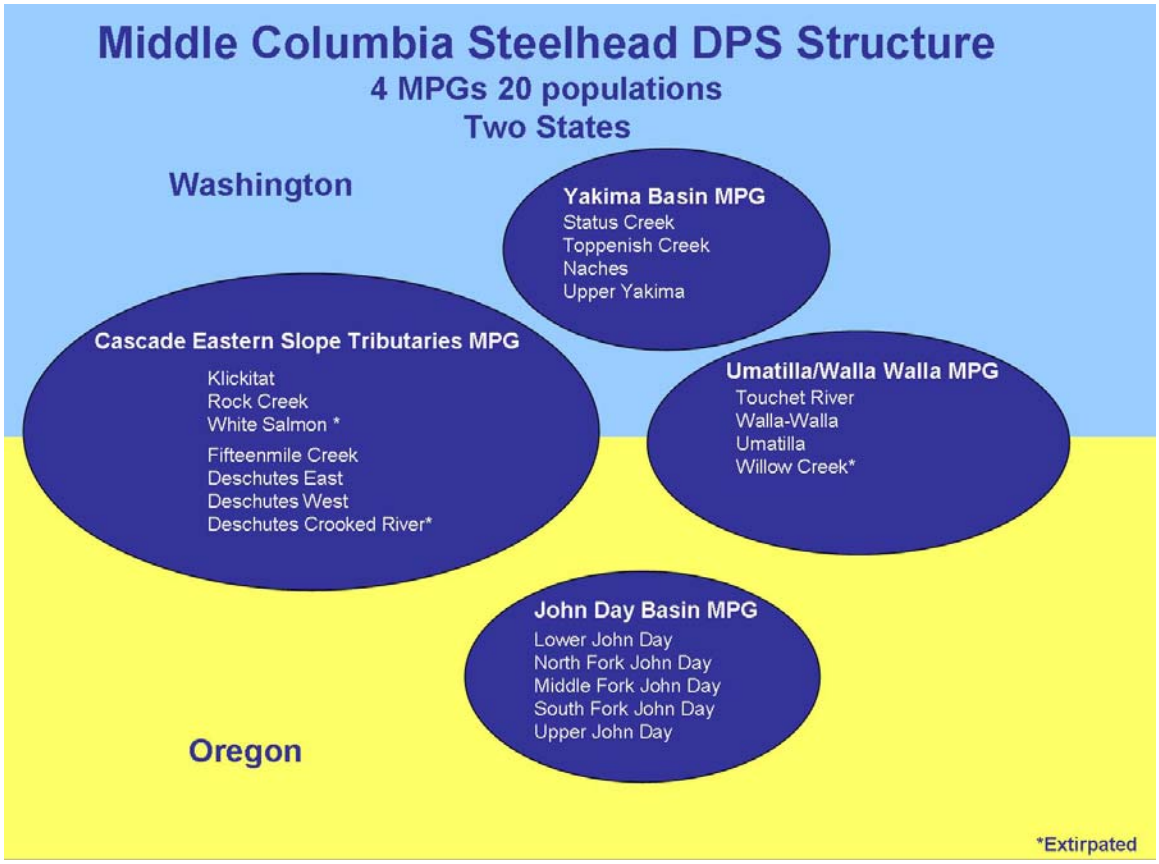


Figure ES-3. Major Population Groups and Populations of Middle Columbia Steelhead.

Historically, the presence of several natural migration barriers in the Klickitat watershed may have limited anadromous fish production, particularly during low water years. The Klickitat River flows through a deep, steep-walled canyon with several historically impassable or marginally passable falls and cascades where the river flows over resistant bedrock. In addition, access to many of the tributaries is restricted because of impassably high gradients or waterfalls close to the tributary mouths. Such historical barriers were important in maintaining separate life history strategies of *O. mykiss*, including summer steelhead, winter steelhead, and resident rainbow trout.

Approximately 102,000 summer-run steelhead from Skamania and Vancouver hatcheries are currently released directly into the Klickitat River annually. Release sites are Leidl Bridge (RM 32), the mouth of the Little Klickitat River (RM 20.2), Wahkiacus Bridge (RM 17), and Pitt Bridge (RM 10.4). The Skamania Hatchery broodstock is maintained by using adult steelhead returning to the Skamania Hatchery on the North Fork of the Washougal River. The original broodstock for the program was established with wild fish taken from both the Washougal and Klickitat River systems. In addition to the hatchery releases of steelhead, an average of 4,349,710 fall Chinook, 595,318 spring Chinook, and 3,714,083 coho are released from the hatcheries into the Klickitat River each year (Sharp et al. 2008). Coho and fall Chinook are not native to the basin upstream of Lyle Falls.

Recovery Goals and Criteria

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act – i.e. to be delisted. Recovery plans may also contain "broad-sense" goals, defined in the recovery planning process, that go beyond the requirements for delisting to address, for example, other legislative mandates or social, economic, and ecological values.

Delisting criteria are applied at the DPS level, and are based on determinations of the viability of the independent populations that make up the DPS. Criteria for delisting the Middle Columbia steelhead DPS are described in the *Middle Columbia River Steelhead ESA Recovery Plan*, to which this plan is an appendix. This chapter provides recovery goals for the Klickitat steelhead population, describes the criteria to be used to assess progress toward those goals, and describes the role of the Klickitat steelhead population in overall DPS viability.

There are two kinds of criteria that enter into a delisting decision: population or demographic parameters (the biological viability criteria) and "threats" criteria related to the five listing factors detailed in the ESA (see Section 1.1). The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B). Both kinds of criteria are discussed in this chapter.

The primary goal of this plan is for the Klickitat steelhead population to be restored to viable status and thus to support recovery of the Mid-Columbia steelhead DPS. A viable salmonid population is defined as an independent population that has negligible risk of extinction over a 100-year timeframe (McElhany et al. 2000).

If a local, collaborative Washington Gorge Recovery Board is formed, it may choose to define additional, broad-sense goals for the Klickitat steelhead population and other steelhead populations within the Washington Gorge Management Unit. The board's broad-sense goals for the area would likely build upon direction already adopted by various stakeholders in the area. These goals would then guide the board as it defines and implements future recovery actions for the Klickitat subbasin.

In the meantime, the Yakama Nation has proposed, as a broad-sense goal for the Klickitat steelhead population, the achievement of "highly viable" status, which corresponds to a one percent risk of extinction over a 100-year period. Achieving highly viable status for the population would provide for long-term, sustainable harvest and other social, cultural, and ceremonial needs, although it would likely exceed the minimum necessary to support delisting the DPS.

The ICTRT developed biologically based viability criteria for ESA-listed salmon and steelhead in the Interior Columbia domain. The ICTRT based its approach to recovery on guidance from the NMFS Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). This

memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels.

The ICTRT criterion for a viable ESU/DPS is that all extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS should be at low risk. The ICTRT provided additional criteria for determining MPG viability (Section 3.2.1). Applying the ICTRT's viability criteria to the Cascades Eastern Slope Tributaries MPG results in the conclusion that the Klickitat steelhead population should reach viable status in order to support overall DPS viability, because of its historical abundance and the presence of both summer and winter runs.

The ICTRT classified the Klickitat steelhead population as an "Intermediate" sized population, based on historical habitat potential (ICTRT 2007) and provided viability criteria for an Intermediate population, as follows (ICTRT 2007):

Abundance

For an Intermediate population, viable status, i.e. a 5 percent or less risk of extinction over a 100-year timeframe, would require a mean minimum abundance threshold of 1,000 naturally produced spawners.

Productivity

Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels.

Spatial Structure and Diversity

In general, the ICTRT defined two goals, or biological or ecological objectives, that spatial structure and diversity criteria should achieve (ICTRT 2007, p. 47):

- Natural rates and levels of spatially mediated processes should be maintained.
- Natural patterns of variation should be maintained.

Threats Criteria and Approach

Section 3.2.2 of the Plan describes the listing factors and listing factor/threats criteria that must be addressed to delist the DPS. The listing factors are the features that were evaluated under ESA section 4(a)(1) when the initial determination was made to list the species for protection.

At the time of a delisting decision, NMFS will use the listing factors/threats criteria to review the status of the section 4(a)(1) listing factors and determine whether the affected DPS is recovered to the point that it no longer requires protections of the ESA. NMFS expects that if the proposed actions described in this and other Middle Columbia River steelhead recovery plans are implemented, the fish will make substantial progress toward meeting the listing factor/threats criteria. These criteria are identified in Section 3.3 and address the five listing factors that were evaluated under section 4(a)(1): 1) the present or threatened destruction, modification, or curtailment of the species' habitat or range; 2) over-utilization for commercial, recreational, scientific or educational purposes; 3)

disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or human-made factors affecting its continued existence.

Current Status Assessment

There are currently neither solid historical data nor accurate metrics for assessing current status of the Klickitat steelhead population. Yakama Nation biologists have provided substantial data, summarized in Chapter 4, which is, however, of a relatively short generational span and limited by significant uncertainties. The first priority for recovery for this population is to reduce these uncertainties with a targeted monitoring program (see Chapter 6, Recovery Strategy and Actions).

The ICTRT reviewed existing data, previous assessment findings, and GIS analysis for its 2005 viability assessment of this population, which is available on the Northwest Fisheries Science Center website, http://www.nwfsc.noaa.gov/trt/trt columbia.cfm.

In this recovery plan the ICTRT viability assessment is presented first, followed by currently available status information from the Yakama Nation. Discussion is also provided of findings from the ICTRT, Yakama Nation, and Klickitat County regarding identification of major and minor spawning areas.

The ICTRT found that the data for steelhead spawning in the Klickitat drainage were insufficient to estimate current abundance. It also found that the productivity of Klickitat steelhead is currently uncertain because both naturally produced and hatchery-origin steelhead return to the Klickitat River. Returns to the Klickitat River include hatchery-origin adults from annual outplants of Skamania summer steelhead stock (approximately 100,000 smolts per year) into the middle sections of the mainstem Klickitat. The spawning success of these hatchery fish is unknown. While redd surveys of steelhead spawning in the Klickitat drainage have been conducted in recent years, there is insufficient coverage to estimate the annual contribution of hatchery vs. natural steelhead in the natural production areas.

Because of insufficient data and the uncertainties regarding naturally occurring production, the ICTRT provisionally assigned the Klickitat River population **Moderate risk** for abundance and productivity (ICTRT 2007).

The ICTRT rated the Klickitat River steelhead population at **Moderate risk** for spatial structure and diversity because of the potential impact on wild steelhead from outside-stock hatchery fish. It determined that reducing the spatial structure/diversity risk to a low rating would require reducing the impacts of the outside-stock hatchery program on natural spawning areas, or determining that the natural population is actually experiencing very little impact from the Skamania stock origin returns.

Limiting Factors and Threats

1. Hatchery influences

Currently there is insufficient information to determine the effects of hatchery releases on the natural steelhead population. While it is likely that hatchery hybridization of Skamania stock with wild steelhead has occurred in the Klickitat subbasin (NPCC 2004),

the level of impact on the natural population remains uncertain. However, based on hatchery release levels and sport catch estimates, the ICTRT found that it is very likely that the hatchery contribution rate to natural steelhead spawning in the Klickitat subbasin has exceeded 5 percent for more than four generations (ICTRT 2007). Straying of out-of-subbasin hatchery-produced steelhead, primarily from the Snake River and Upper Columbia, into the Klickitat subbasin may also affect the viability of the Klickitat steelhead population.

Coho and fall Chinook are not native, but have naturalized in the basin as a result of hatchery releases and are known to spawn in relatively large numbers (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009). The effects of these hatchery releases and/or the subsequently naturalized species on the Klickitat River steelhead population are unknown.

2. Habitat

Habitat factors that likely limit steelhead production in the Klickitat watershed are affected by past and/or current land use practices that stress naturally occurring conditions. For example, while low summer flows and high summer water temperatures occur naturally in some parts of the watershed because of bedrock terrain and steep slopes, anthropogenic changes in the subbasin may have increased the intensity of such factors. The habitat factors that potentially limit steelhead abundance, productivity, spatial structure, and diversity within the Klickitat watershed are the following: lack of key habitat quantity and habitat diversity, loss of floodplain function, altered hydrology, degraded channel structure, obstructed fish passage, increased fine sediment delivery, high water temperature, and altered food web. Chapter 5 and Appendix II provide more detail on these factors, as well as their potential effects on steelhead viability.

3. Harvest

Tributary recreational steelhead fisheries in the Klickitat River are selective for marked hatchery steelhead; the release of unmarked wild steelhead is required. In the Klickitat River, the recreational fisheries impact on wild summer-run steelhead is estimated to be 6 percent and for winter-run steelhead 3 percent (WDFW 2003). Treaty Native American fisheries also occur in the mainstem Klickitat River. The treaty Native American catch of all types of steelhead (summer and winter, wild and hatchery combined) in the Klickitat River is estimated at an average of 1,146 steelhead per year since 1986 (Sharp et al. 2008). Estimated tribal harvest of wild steelhead in the Klickitat averages 178 fish per year (Table 2-1) (Sharp et al. 2008).

4. Out-of-Subbasin Factors

Out-of-subbasin limiting factors and threats are discussed briefly in Section 5.4. The 2008 Biological Opinion on the operation of the FCRPS, and particularly the Supplemental Comprehensive Analysis (NMFS 2008a). http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/Final-BOs.cfm, details the influences from the Columbia River hydrosystem. The Columbia River Estuary Module http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery -

Plans/upload/Estuary-Module.pdf discusses factors that may limit the viability of Klickitat steelhead in the Columbia River estuary.

Recovery Strategy and Actions

The rationale linking what is known about the population's current conditions and the actions that should be taken to achieve recovery is called the recovery strategy.

Lack of information about the Klickitat River steelhead population is a major problem for recovery planning for the Middle Columbia River steelhead DPS. Using the ICTRT criteria for DPS viability, this population (among others) needs to be viable for the DPS to be viable. The Klickitat population's moderate risk rating was assigned primarily on the basis of uncertainty and lack of data, particularly with respect to the influence of hatchery fish on the wild steelhead population. Therefore, the first importance for a recovery strategy is to reduce the uncertainties by obtaining more information.

A targeted monitoring program is needed for the following purposes:

- To determine abundance and productivity of natural spawners
- To determine the proportion of hatchery and wild spawners in the Klickitat subbasin.
- To determine the adverse effects of Skamania broodstock on the Klickitat population, if any.
- Continue study and further refine understanding of habitat limiting factors.

The Yakama Nation is working with NMFS, WDFW, tribal fish and wildlife leaders, and others to develop a master plan for an integrated hatchery program for the Lower Klickitat River. The program will minimize adverse impacts on the natural steelhead spawning population. One option being explored by hatchery program managers is to replace the current program, which releases out-of-basin Skamania hatchery-origin smolts in the Klickitat River system, with a hatchery program that relies entirely on the use of natural-origin summer steelhead from the Klickitat River for broodstock. The new program would continue to provide harvest opportunities for treaty and non-treaty fisheries. A feasibility study would likely be conducted as part of the program to investigate broodstock collection and juvenile rearing strategies, expected smolt-to-adult survival rates, and the risks associated with current steelhead hatchery practices.

The Yakama Nation also is working with NMFS, WDFW, tribal leaders, and others to examine whether a conservation hatchery program could be used to accelerate recolonization of the Upper Klickitat watershed. The program could also be used to provide harvest opportunities. The need for, and use of, artificial production to accelerate recolonization would be contingent upon the rate and extent that natural recolonization occurs in the upper watershed now that passage has been restored at Castile Falls. The decision to implement an artificial propagation program in the upper Klickitat watershed would likely imply that natural recolonization has been minimal and/or is occurring at an extremely slow rate. The draft Klickitat River Anadromous Fisheries Master Plan, which describes in detail these hatchery actions, was submitted for review to fulfill the requirements for step one of the NPPC's three-step process for major projects (WDFW and Sharp et al. 2008).

Habitat conditions (e.g. high water temperatures in some tributaries) and the various natural and constructed migration barriers are considered to be limiting factors for the Klickitat steelhead population. Protecting the existing good quality habitat, restoring habitat where appropriate, and improving access to spawning areas would likely improve abundance, productivity, spatial structure, and diversity for this population. Further identification of the factors limiting the Klickitat population is a priority action.

Managing harvest to maintain current low impacts from both mainstem and tributary fisheries, and to reduce any adverse impacts that may be occurring, also is an important contribution to the population's viability.

The actions recommended to support recovery are described in more detail in the following sections. Table ES-1 organizes priority actions in terms of larger categories, called strategies. Out-of-basin recovery strategies and actions are addressed in two NMFS documents, The Columbia River Estuary Module, available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm, and the 2008 FCRPS Biological Opinion (NMFS 2008c).

Table ES-1. Recovery Strategies and Actions for the Klickitat River Steelhead Population.

Strategy	Key Types of Actions
Hatchery	
Determine impact of hatchery steelhead releases on viability of Klickitat steelhead population.	• Conduct annual spawner surveys to track adult steelhead occupancy of MaSAs. • Sample carcasses on spawning grounds to estimate natural/hatchery adult spawner ratios. • Increase juvenile and adult genetic sampling and analysis at spawning grounds and at various trap locations to assess level of domestication and interbreeding between hatchery and natural steelhead. • Conduct radio-tagging study to determine spatial and temporal distribution of natural population and Skamania Hatchery steelhead, and overlap between summer and winter runs.
Minimize adverse impacts of hatchery releases on natural steelhead spawning population.	• Develop and implement Klickitat steelhead integrated hatchery program. • Conduct feasibility study to gain needed information on broodstock collection, rearing strategies and expected smolt-to-adult survival rates, and to assess risks associated with current and proposed hatchery practices.
Improve steelhead passage at Lyle Falls Fishway.	• Reconstruct Lyle Falls Fishway to Federal design criteria to ease passage of steelhead and to possibly function as the broodstock collection facility.
Assess steelhead natural recolonization of upper Klickitat watershed and the potential use of artificial propagation to accelerate recolonization.	• Monitor annual natural escapement of steelhead into the upper subbasin. • Use Castile Fishway trap to collect biological data on *O. mykiss* migrating into the upper watershed, and to monitor trends in the genetic composition and diversity of the upper basin population. • Explore need for a conservation hatchery program to accelerate recolonization of upper Klickitat watershed.
Minimize adverse impacts of large-scale hatchery releases of *U.S. v. Oregon* production stocks (coho and fall Chinook) on Klickitat steelhead.	• Develop the satellite Wahkiacus Hatchery/Acclimation Facility at RM 17.0. • Transfer existing *U.S. v. Oregon* production of fall Chinook and coho from Klickitat Hatchery to new Wahkiacus facility.
Determine and minimize impacts of hatchery trout releases in the subbasin.	• Investigate impacts of WDFW hatchery trout plants into the Klickitat subbasin.
Determine the effects of hatchery releases of coho and fall Chinook and subsequent naturalization of the species on Klickitat River steelhead	• Conduct annual spawner surveys to document adult coho and fall Chinook occupancy. • Sample carcasses on spawning grounds to estimate natural/hatchery adult spawner ratios. • Develop population estimates of naturally spawning coho and fall Chinook and evaluate productivity of those species. • Conduct studies as needed to determine the effect of coho and fall Chinook on steelhead population.
Tributary Habitat	
Protect stream corridor structure and function	• Protect highest quality habitats through land acquisition, conservation easements or land trusts with willing landowners. • Adopt and manage Cooperative Agreements where beneficial. • Conserve rare and unique functioning habitats. • Consistently apply Best Management Practices and existing laws to protect and conserve natural ecological processes.
Restore passage and connectivity between habitat areas.	• Monitor effectiveness of passage improvements at Castile Falls. • Remove or replace barriers blocking or impairing passage including dikes, road culverts and irrigation structures. • Monitor and continue restoration efforts in Snyder Creek mill reach. • Ensure that pump intakes are adequately screened.
Restore riparian condition	• Restore natural riparian vegetative communities. • Develop grazing strategies that promote riparian recovery. • Monitor and continue restoration efforts in Snyder Creek mill reach.

Strategy	Key Types of Actions
Restore altered hydrographs to enhance instream flows during critical periods	• Implement agricultural water conservation measures. • Improve irrigation conveyance and efficiency. • Employ BMPs to forest, agriculture and grazing practices and to road management. • Assess effects of groundwater development on tributary flow. • Protect and/or rehabilitate springs • Increase pool habitat.
Restore water quality, including water temperatures.	• Increase riparian shading where stream temperatures are high • Assess nutrient and dissolved oxygen levels in the Little Klickitat River, particularly downstream of Goldendale. • Employ BMPs for forest, agriculture and grazing practices and for road management. • Upgrade or remove problem forest roads.
Harvest	
Manage to maintain current low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts.	Maintain current management regulations for low impact fisheries and adjust tributary harvest regulations in areas where harvest significantly impacts steelhead viability.
Study and limit adverse impacts of harvest practices in Klickitat subbasin on ESA-listed species.	Eliminate illegal harvest by enforcing tribal and sport regulations in Klickitat subbasin.
Monitoring	
Monitor to determine abundance and productivity of natural spawners, proportion of hatchery and wild spawners in the Klickitat subbasin, and adverse effects, if any, of Skamania broodstock on Klickitat steelhead population.	• Continue to enumerate upstream adult migrants and downstream migrating smolts at the fish traps • Develop estimates of the efficiencies of the traps • Annually estimate the abundance of the adult and smolt populations • Develop annual estimates of productivity of natural spawners Develop improved methods for estimating abundance and productivity of natural spawners.

Cost Estimates

The highest priority strategies for the Klickitat basin address data gaps (see Section 6-1). As such, these priority strategies fall into the category of research, monitoring, and evaluation. The costs associated with these efforts are detailed in Chapter 8. Table 8-1 estimates the cost of ongoing and expanded RM&E activities to be up to $4,484,402 for years 1 through 3, and up to $15,142,783 for years 4 through 10. Information gained through filling the priority data gaps will help to refine the actions needed to reach recovery.

Costs for actions to address hatchery-related effects are distributed among research, monitoring and evaluation, detailed in Chapter 8, and capital costs and operations and maintenance costs that have been included in programs proposed under the NPCC Fish and Wildlife Program or are ongoing under that program or the Mitchell Act administered by NMFS. Capital costs for hatchery and fish passage improvements are estimated at $41.6 million; these are proposed as part of the Klickitat River Anadromous Fisheries Master Plan, submitted to the NPCC in 2008 (Sharp et al. 2008). Ongoing operations and maintenance costs are not included in the total cost of recovery calculated for the plan, per NOAA guidance for cost estimating (Plummer 2006).

The total estimated cost for completing all of the habitat projects identified in Chapter 6 is estimated to be up to $129,451,630 ($25,890,326.00 for years 1-10, and

$103,561,304.00 for years 11-50). Estimates are expressed in 2007 dollars. Estimated costs are general range summaries arranged to align with the Klickitat River Anadromous Fisheries Master Plan (Sharp et al. 2008) and Yakima/Klickitat Fisheries Project.

Implementation

NMFS has worked independently with the Yakama Nation, Washington Department of Fish and Wildlife, and local entities to develop the recovery plan for the Klickitat steelhead population. NMFS encourages the formation of a planning forum for the Washington Gorge Management Unit, a forum or entity that would take responsibility for coordinating implementation of the plan. The creation of a Washington Gorge Area Regional Board (subject to concurrence by state, tribal and local governments, including the Yakama Nation) would provide a *collaborative process* for further prioritizing recovery actions and for implementation of the Washington Gorge Management Unit plans.

Implementation of the Klickitat Subbasin Recovery plan involves addressing data gaps through research, monitoring, and evaluation; establishing schedules and priorities for recovery actions; engaging stakeholders and landowners; identifying responsibilities; and securing funding. Implementation of this plan depends on the voluntary actions and cooperation of local entities and citizen groups. An important part of implementation will be working cooperatively to develop a detailed research, monitoring, and evaluation plan addressing the additional information needs described in Chapter 8.

Funding sources for salmon and steelhead recovery actions in the Columbia Basin are varied. They include:

- Pacific Coastal Salmon Recovery Fund (PCSRF) (States and tribes)
- Salmon Recovery Funding Board (SRFB) (a combination of PCSRF and Washington State funds)
- Columbia Basin Fish Accords
- Congressional appropriations (Federal agencies)
- State appropriations (state agencies)
- Northwest Power and Conservation Council Fish and Wildlife Program (states and tribes)
- Federal / state grants
- Non-profit organization programs and grants

The 2008 Columbia River Fish Accords Memorandum of Agreement between the Three Treaty Tribes and FCRPS Action Agencies identifies funds for hatchery planning and operations and maintenance covering some of the existing and expanded activities in the Klickitat River basin. The Accords identify hatchery capital funds for the design and construction of the hatchery and passage facilities in the Klickitat River basin except the Wahkiacus Hatchery facility, and include language that states that the Action Agencies will work toward finding funding for this facility.

Research, Monitoring, and Adaptive Management

As part of implementing the Klickitat recovery plan, a detailed monitoring and evaluation program will be designed and incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS guidance document, *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance.*

The Klickitat monitoring and evaluation program will build on existing programs designed for monitoring tributary habitat in the subbasin, hydropower actions in the Mid-Columbia, Mid-Columbia hatchery programs, and other actions outside of the Mid-Columbia tributary subbasins (e.g., Columbia mainstem hydropower, estuary and ocean conditions, mainstem and ocean harvest). The monitoring and evaluation program will provide (1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed, (2) a plan for tracking such metrics and indicators, and (3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the plan's goals.

1. Introduction

The Endangered Species Act of 1973 (ESA) requires NOAA's National Marine Fisheries Service (NMFS) to develop recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA.

This recovery plan focuses on the conservation and survival of Middle Columbia River steelhead (*Oncorhynchus mykiss*) in the Klickitat subbasin (Figure 1-1). The Klickitat River drains approximately 1,350 square miles in south central Washington before joining the Columbia River at Lyle, Washington (RM 180.4), 34 miles upstream of Bonneville Dam. The Klickitat is one of the longest undammed rivers in the Northwest. The subbasin supports both summer and winter runs of steelhead.

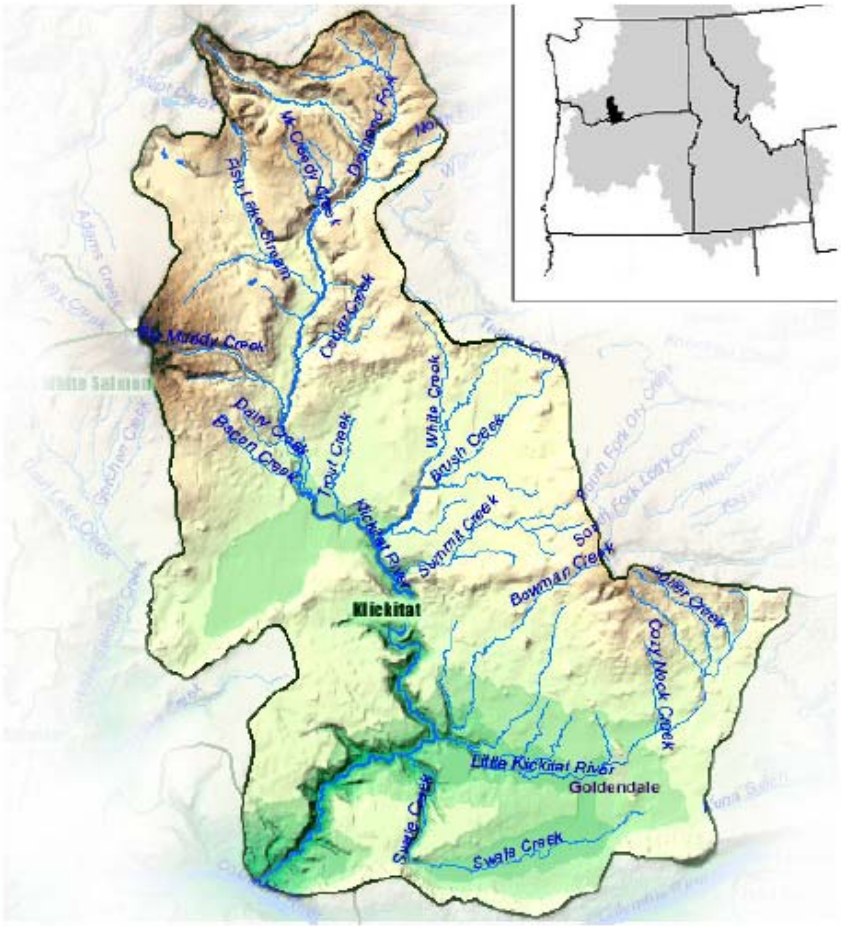


Figure 1-1. Klickitat Subbasin.

"Steelhead" is the name commonly applied to the anadromous form of the biological species *Oncorhynchus mykiss*. The species also has a non-anadromous, or resident, form

that is commonly called rainbow trout. NMFS originally listed the species as threatened on March 25, 1999 (NMFS 1999), calling it an "evolutionarily significant unit" (ESU) of salmonids, which included both forms. Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS). NMFS listed the Middle Columbia River steelhead DPS as threatened on January 5, 2006 (NMFS 2006a, 71 FR 834). The DPS is made up of steelhead populations in Oregon and Washington tributaries of the Columbia River upstream of the Hood and Wind River systems, up to and including the Yakima River. Reasons for listing the Middle Columbia River steelhead DPS included low returns to the Yakima River, poor abundance estimates for Klickitat River and Fifteenmile Creek winter steelhead, and an overall decline of naturally producing "stocks" within the DPS.

The Klickitat River population is of particular interest because of containing both summer and winter runs, and it potentially could make a significant contribution to recovery of the Middle Columbia steelhead. The Klickitat River is one of the largest salmon producing watersheds in the Columbia basin. It is located above only one dam (Bonneville), contains headwaters in the well-managed forests of the Yakama Reservation, and has had relatively little development, with relatively low human population growth expected in the near future. Recent passage improvements at Castile Falls in the upper Klickitat have opened an additional 56 miles of high quality steelhead habitat. Passage improvements in the lower Klickitat (Lyle Falls at RM 2.2) are also expected to benefit immigrating adults. In addition, a hatchery master plan under development by the Yakama Nation in consultation with NMFS is expected to improve hatchery management to support conservation of the naturally spawning steelhead.

NMFS developed this recovery plan with involvement and input from the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal agencies, state agencies, local governments, and the public. While NMFS is the agency responsible for recovery planning for salmon and steelhead under the ESA, NMFS believes it is critically important to base ESA recovery plans for salmon on the many state, regional, tribal, local, and private conservation efforts already underway throughout the region. Local support of recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential. NMFS therefore supports and participates in locally led collaborative efforts to develop recovery plans, involving local communities, state, tribal, and Federal entities, and other stakeholders.

1.1 Purpose of Plan

The Plan provides a roadmap for restoring the Klickitat steelhead population and its habitats to a level that supports recovery of the Middle Columbia River steelhead DPS and allows the population to become a viable component of its ecosystem.

The Plan is a guidance document. It describes the current status of the Klickitat population and its habitat in the Klickitat drainage, and summarizes the results of a technical assessment examining the population's viability. The Plan also identifies the

factors and threats potentially limiting the population and proposes strategies and actions designed to aid in the population's recovery by building on past and current efforts. Finally, the Plan provides an implementation and adaptive management framework for making needed future adjustments on the road to recovery.

1.1.1 ESA Requirements

Section 4(f) of the ESA requires that a recovery plan be developed and implemented for species listed as endangered or threatened under the statute.

ESA section 4(a)(1) lists factors for re-classification or delisting that are to be addressed in recovery plans:

A. The present or threatened destruction, modification, or curtailment of [the species'] habitat or range
B. Over-utilization for commercial, recreational, scientific or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting its continued existence

ESA section 4(f)(1)(B) directs that recovery plans, to the extent practicable, incorporate:

1. a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
2. objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this chapter, that the species be removed from the list; and;
3. estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In addition, it is important for recovery plans to provide the public and decision makers with a clear understanding of the goals and scientifically supported strategies needed to recover a listed species (NMFS 2006b).

Once a species is deemed recovered and therefore removed from a listed status, section 4(g) of the ESA requires the monitoring of the species for a period of not less than five years to ensure that it retains its recovered status.

1.1.2 Coordination with Others

The Plan aims to provide consistency among related recovery planning and management efforts, including NOAA's Federal treaty and trust responsibilities and the many state and local entities involved in salmon recovery.

Federal Treaty and Trust Responsibilities

Northwest Native American tribes have legally enforceable treaty rights reserving to them a share of the harvestable salmon and steelhead. Achieving the basic purposes of the ESA such that the species no longer needs the protection of the Act may not by itself

fully meet these rights and expectations, although it will lead to major improvements in the current situation. Ensuring a sufficient abundance of salmon to sustain harvest can be an important element in fulfilling trust and treaty rights as well as garnering public support for these plans.

It is NMFS policy that recovery of salmonid populations must achieve two goals: (1) the recovery and delisting of salmonids listed under the provisions of the ESA, and (2) the restoration of the meaningful exercise of tribal fishing rights. "It is the agency's view that there is no conflict between the statutory goals of the ESA and Federal trust responsibility to Indian tribes" (Letter from Terry Garcia, Assistant Secretary for Oceans and Atmosphere, to Ted Strong, Executive Director, Columbia Inter-Tribal Fish Commission, July 21, 1998). Additionally, NMFS "will continue to join with states and tribes to develop a comprehensive approach to the restoration of fish and wildlife resources in a manner that fulfills all obligations under Federal law, including trust obligations to Indian tribes" (ibid.).

Thus, it is appropriate for recovery plans to take these considerations into account and plan for a recovery strategy that includes harvest. In some cases, the desired abundances for harvest may come about through increases in the naturally spawning population. In others, the recovery strategy may include appropriate use of hatcheries to support a portion of the harvest. So long as the overall plan is likely to achieve the biological recovery of the listed ESU, it will be acceptable as a recovery plan.

Treaty Native American fishing rights in the Columbia basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon*, No. 68-513 (filed in 1968). The parties to *U.S. v. Oregon* are the United States acting through the Department of Interior (USFWS and Bureau of Indian Affairs) and Department of Commerce (NMFS), the Warm Springs, Umatilla, Nez Perce, Yakama, and Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho. In *U.S. v. Oregon*, the Court affirmed that the treaties reserved for the tribes 50 percent of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas.

The Klickitat watershed is part of the Yakama Nation's ceded area. Yakama Nation staff developed much of the data on the Klickitat population. The Yakama Nation is voluntarily participating in recovery planning and implementation in the Yakima subbasin and throughout its ceded area as a sovereign with treaty-reserved rights on and off the reservation, and as a fish and wildlife co-manager. In so doing, the Yakama Nation does not waive or in any way alter its treaty-reserved rights.

Other Federal, State and Local Responsibilities

To ensure consistency in goals, strategies, and actions and to eliminate needless duplication of effort, the process aims to provide consistency between planning for ESA recovery, the Northwest Power and Conservation Council (NPCC) Fish and Wildlife Program, the State of Washington Watershed Management and Salmon Recovery Programs, and local planning and regulatory efforts.

This recovery plan follows ESA guidelines and builds upon direction in the Klickitat Subbasin Plan (NPCC 2004). The 2004 Klickitat Subbasin Plan was developed for the NPCC by the Yakama Nation, Washington Department of Fish and Wildlife, and other Federal, state, and local entities. It contains an assessment and inventory of fish and wildlife resources in the subbasin, as well as a management plan establishing locally informed fish and wildlife protection and restoration priorities. The NPCC adopted the Klickitat Subbasin Plan into its Fish and Wildlife Program in 2004. The NPCC and Bonneville Power Administration use the Klickitat Subbasin Plan to direct funding for projects that protect, mitigate, and enhance fish and wildlife that have been adversely impacted by the development and operation of the Columbia River hydropower system, pursuant to their obligations for implementing the Northwest Power Act of 1980.

Information and direction was also drawn from the Watershed Management Plan for Watershed Resource Inventory Area (WRIA) 30, the Klickitat drainage. The Watershed Management Plan was developed and approved in accordance with Chapter 90.82 Revised Code of Washington (Chapter 90.82 RCW). The "initiating governments" for the planning effort were Klickitat County, City of Goldendale, and Public Utility District No. 1 of Klickitat County (KPUD). The Watershed Management Plan provides for 5 years of funding for watershed plan implementation via the WRIA planning organization.

1.2 Context of Plan Development

This plan for the Klickitat steelhead population is one part of a larger effort to recover species listed throughout the Pacific Northwest. Not only is it one of several recovery plans for steelhead populations in the Middle Columbia River steelhead DPS, it is also one of many recovery plans within NMFS' larger framework of recovery planning efforts for listed salmon and steelhead populations across the Pacific Northwest.

Currently 13 ESUs and 6 DPSs of Pacific salmon and steelhead in the Pacific Northwest are listed under the ESA. NMFS has designated five geographically based recovery domains for preparing recovery plans for the listed species. The Middle Columbia River steelhead DPS falls within the Interior Columbia recovery domain (which is divided into three sub-domains: the Snake River, Mid-Columbia, and Upper Columbia). The other recovery domains are the Willamette/Lower Columbia, Puget Sound and Washington Coast, Oregon Coast, and the Southern Oregon/Northern California Coast. (http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Middle-Upper-Columbia/Index.cfm). Similar opportunities for technical and stakeholder involvement exist in each domain.

1.2.1 Technical Recovery Teams

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each Technical Recovery Team (TRT) was to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population viability criteria – criteria to be used, along with criteria based on mitigation of the factors for decline, to determine whether a species has recovered sufficiently to be downlisted or delisted. These principles are described in a NMFS technical memorandum, *Viable Salmon Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). Viable salmonid populations (VSP) are defined in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework, based on data availability, the unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs are working from a common scientific foundation.

The Interior Columbia Technical Recovery Team (ICTRT) provided technical support for the Mid-Columbia River steelhead DPS recovery planning effort. The ICTRT included biologists from NMFS, state and tribal entities, and academic institutions.

1.2.2 Planning Forums

In each domain, NMFS has worked with state, tribal, local and other Federal entities to develop planning forums that build to the extent possible on ongoing, locally led recovery efforts. NMFS defined "management units" based on jurisdictional boundaries as well as areas where citizen planning efforts were underway. The Mid-Columbia management units are (1) Oregon; (2) Washington Gorge, which, in turn, is subdivided into three planning areas, White Salmon, Klickitat, and Rock Creek; (3) Yakima subbasin; and (4) Southeast Washington. These management units have active planning and implementation forums, with the exception of the Washington Gorge Management. In the Washington Gorge Management Unit, NMFS has worked independently with the Yakama Nation, Washington Department of Fish and Wildlife (WDFW), Klickitat County, and local entities to develop the recovery plan for the Klickitat steelhead population. NMFS encourages the formation of a planning forum for the Washington Gorge Management Unit (Figure 1-2).

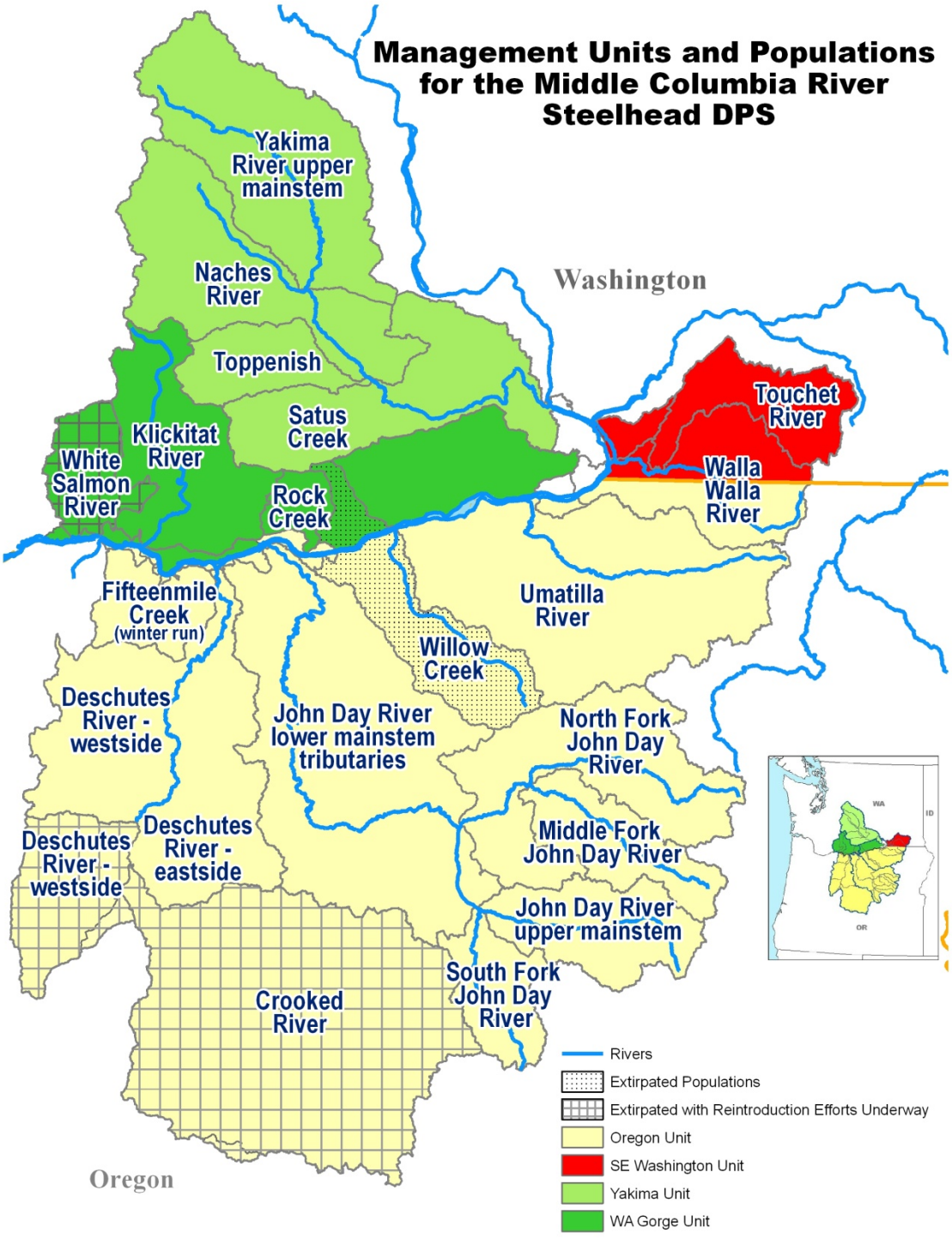


Figure 1-2. Management Units for Middle Columbia River Steelhead DPS.

1.3 How NMFS Intends to Use the Plan

Although recovery plans are not regulatory and their implementation is voluntary, they are important tools that help to do the following:

- Provide context for regulatory decisions.
- Guide decision making by Federal, state, tribal, and local jurisdictions.
- Provide criteria for status reporting and delisting decisions.
- Organize, prioritize, and sequence recovery actions.
- Organize research, monitoring, and evaluation efforts.

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions carried out to meet Federal ESA section 7(a)(1) obligations
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10
- Hatchery and Genetic Management Plans and permit requests
- Harvest plans and permits
- Selection and prioritization of subbasin planning actions
- Development of research, monitoring, and evaluation programs
- Revision of land use and resource management plans
- Other natural resource decisions at the state, tribal, and local levels

NMFS will emphasize recovery plans in ESA section 7 (a)(2) consultations, section 10 permits, and application of the section 4(d) rule by considering:

- Delisting criteria that address both viability and threats
- Description of limiting factors and threats (factors for decline)
- Description of a recovery program (site-specific management actions necessary to achieve recovery of the species)
- Estimates of the time and cost to carry out measures to achieve the plans' goals

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. NMFS staff will encourage the Federal "Action Agencies" to describe in their biological assessments how their proposed actions will affect specific populations and limiting factors identified in the recovery plans, and to describe any mitigating measures and voluntary recovery activities in the action area.

2. Biological Background

This chapter describes population and habitat characteristics for Middle Columbia River steelhead in the Klickitat subbasin. The chapter also discusses hatchery production and releases and harvest management in the Klickitat subbasin.

2.1 Populations and Major Population Groups

The ICTRT identified 17 extant and 3 extirpated independent steelhead populations in the Middle Columbia River steelhead DPS (McClure et al. 2003). These populations are shown in Figure 2-1. The ICTRT delineated the populations based on genetic information, geography, life history traits, morphological traits, and population dynamics.

The ICTRT grouped these independent populations into four major population groups (MPGs) within the DPS: the Cascades Eastern Slope Tributaries MPG, Yakima subbasin MPG, John Day River MPG, and Umatilla/Walla Walla MPG. The Klickitat River population is one of five extant populations (Klickitat River, Fifteenmile Creek, Rock Creek, Deschutes Eastside, and Deschutes Westside) and two extirpated populations (White Salmon River and Deschutes Crooked River) comprising the Cascades Eastern Slope Tributaries MPG (Figure 2-2). Populations in the group are united primarily by proximity and occupy diverse habitats, generally those draining the eastern slopes of the Cascades and the Columbia Plateau.

2.2 Physical Setting

The Klickitat River drains an area of approximately 1,350 square miles in south central Washington. It begins in the Cascades Mountains below Cispus Pass near 5,000 feet elevation and flows just over 95 miles to join the Columbia River at Lyle, Washington (RM 180.4), 34 miles upstream of Bonneville Dam (elevation 74 feet). It is one of the longest undammed rivers in the Northwest. The Klickitat drainage stretches west to the Cascade Mountain crest, north and east to the basalt ridges and plateaus of the Yakama Reservation, and south to the Columbia River Gorge. Major tributaries to the Klickitat River include Swale Creek (RM 17.2), Little Klickitat River (RM 19.8), Outlet Creek (RM 39.7), Big Muddy Creek (RM 53.8), West Fork Klickitat River (RM 63.1), and Diamond Fork (RM 76.8) (NPCC 2004). Major Creek is a small tributary to the Columbia River that lies just downstream of the Klickitat River drainage and is believed to support Middle Columbia steelhead. Appendix I provides an overview of the Major Creek watershed and current knowledge concerning steelhead use.

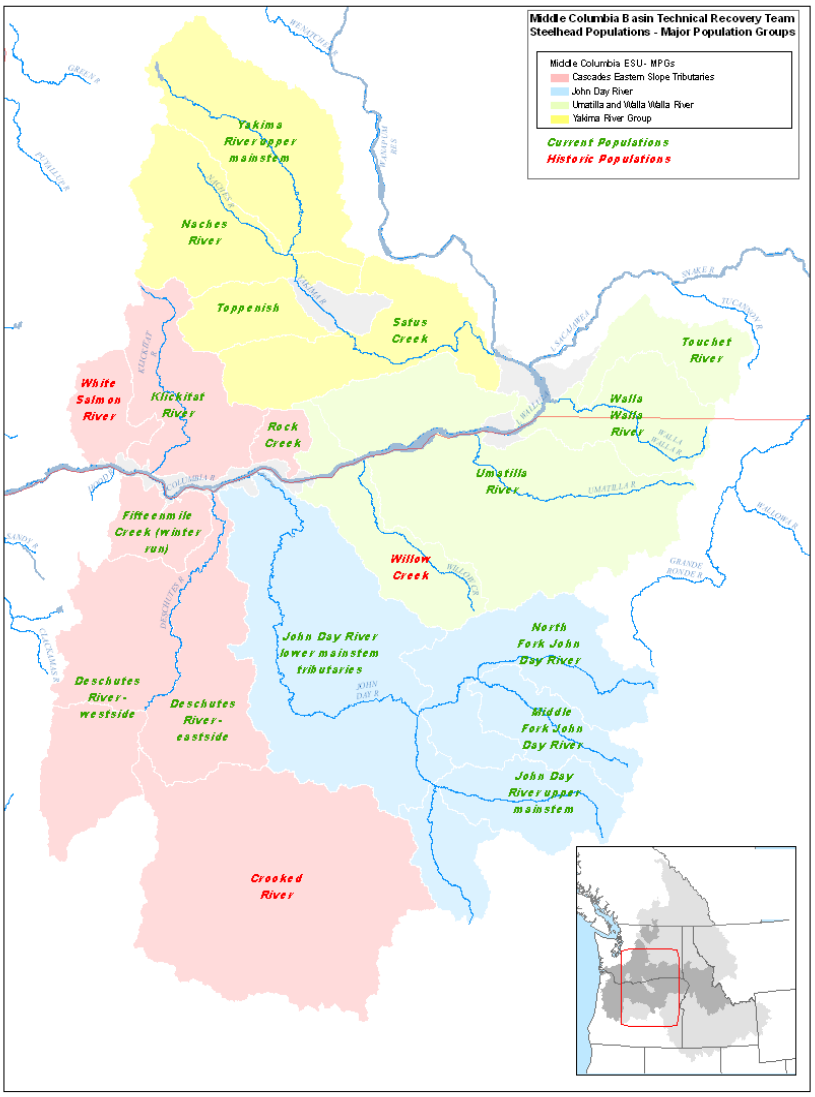


Figure 2-1. Independent Populations in the Middle Columbia River Steelhead DPS.

Forests cover three-quarters of the watershed: the Yakama Nation is the primary timberland landowner. These lands are managed according to the Yakama Nation Forest Management Plan, which designates the Klickitat watershed a "Reserve Area," where no timber harvest is planned. The State of Washington and numerous private parties own the remaining forested land, which is managed pursuant to the State Forest Practices Rules and an approved Habitat Conservation Plan (HCP). The rest of the watershed is used primarily for pasture, orchards, dry-land farming and livestock grazing. Agricultural use is concentrated in the Glenwood/Camas Prairie area in the western part of the watershed and on the southeastern plateau. Portions of the southernmost part of the Klickitat subbasin are within the Columbia River Gorge National Scenic Area (extending roughly 3 miles upstream from the mouth) (http://www.fs.fed.us/r6/columbia/maps/map.htm). The lower 10 miles of the Klickitat River are designated as a Recreational River under the National Wild and Scenic Rivers Act (http://www.rivers.gov/wsr-klickitat.html). The

Klickitat Wildlife Area, owned and managed by WDFW, covers 14,700 acres, encompasses a significant portion of the Klickitat River between the confluence with the Little Klickitat River and White Creek, as well as smaller segments of land along the lower river, downstream of the Little Klickitat River http://www.ecy.wa.gov/services/gis/maps/wria/mpl/mpl30.pdf. Columbia Land Trust recently acquired for conservation the west bank of the Klickitat River extending from just below the confluence with the Little Klickitat River north approximately 15 miles.

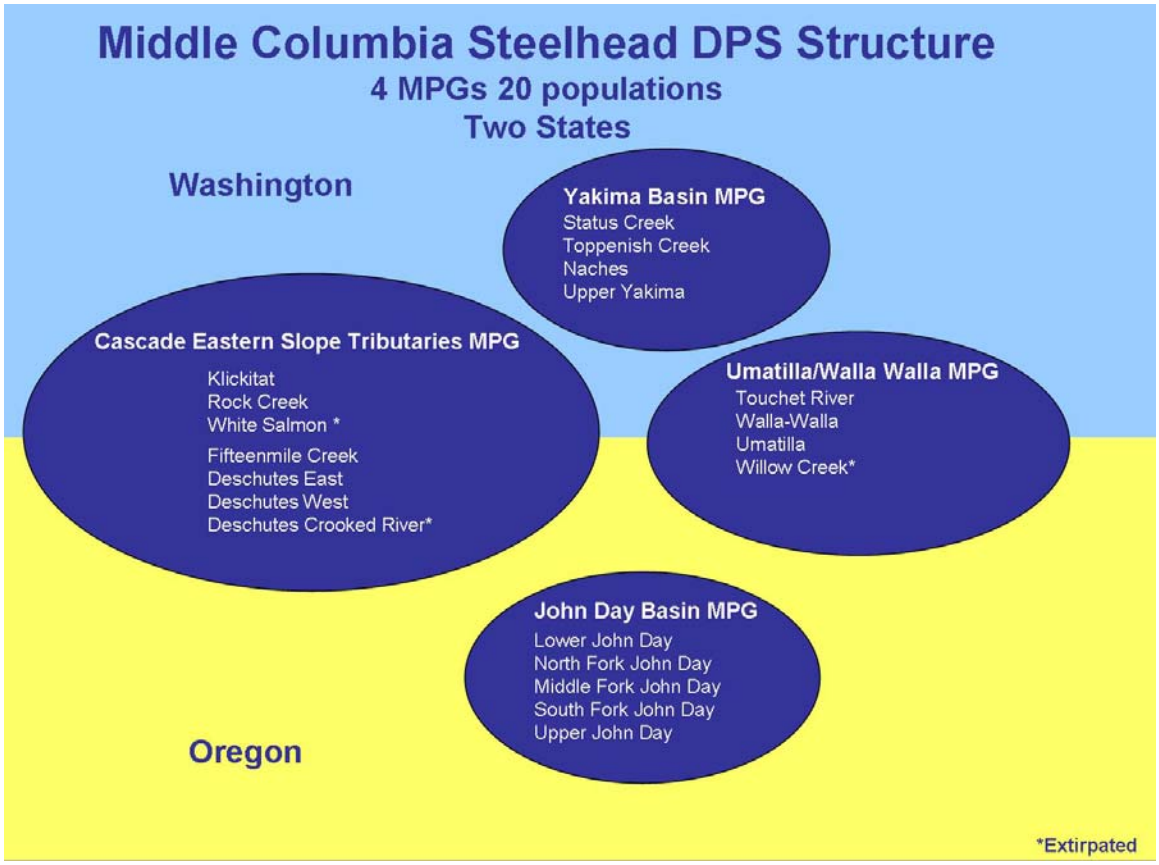


Figure 2-2. Major Population Groups and Populations of Middle Columbia Steelhead.

Several entities share responsibility for land and water management in the Klickitat subbasin (Figure 2-3). The subbasin is almost equally divided between Klickitat and Yakima counties. The City of Goldendale is the Klickitat County seat. The City of Yakima is the Yakima County seat. The subbasin supports a total population of approximately 11,000 people. As of the 2000 census, the City of Goldendale had a population of 3,760 (www.census.gov). The towns of Klickitat, Lyle, and Glenwood are unincorporated. The Yakama Nation is also a caretaker of subbasin resources. The Yakama Reservation comprises 1,573 square miles in Klickitat and Yakima counties. About a third of the Klickitat watershed, including the headwaters of the Klickitat River, lies within the reservation. The Yakama Nation ceded the rest of the Klickitat area in the June 9, 1855 treaty with the United States, reserving fishing, hunting and gathering rights, among other rights and responsibilities. The Klickitat watershed contains a "usual and accustomed fishing area" of historical, traditional, and modern cultural significance

at Lyle Falls. In addition, the subbasin falls within Washington's Middle Columbia River Salmon Recovery Region ─ one of several Salmon Recovery Regions designated within Washington State ─ which includes salmon-bearing streams in Benton, Kittitas, Yakima, and parts of Chelan and Klickitat counties. It is also designated as the state's Water Resource Inventory Area (WRIA) 30.

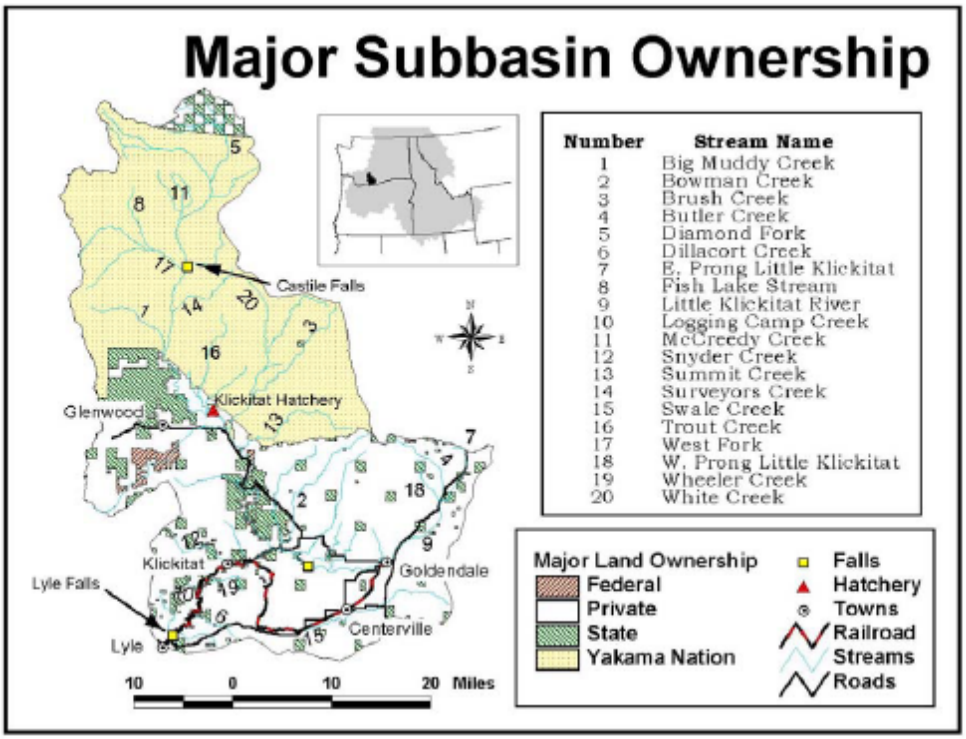


Figure 2-3. Klickitat Subbasin Land Ownership, Towns and Stream Locations (NPCC 2004).

2.3 Ecosystem Conditions

The Klickitat subbasin consists primarily of a basalt plateau with a total thickness of several thousand feet (Cline 1976), which is dissected by deep, steep-walled canyons carved by the watershed's network of streams and rivers. The Klickitat River, for example, flows through a deep canyon (700 to 1500 feet deep), and most of its tributaries are similarly incised. The erosion-resistant nature of some of the basalt strata has caused the formation of numerous waterfalls that restrict fish movement, including three notable waterfalls: Lyle Falls (RM 2.2 on the mainstem Klickitat River), Castile Falls (RM 64.0 to 64.5 on the mainstem Klickitat River), and Little Klickitat Falls (RM 6.1 on the Little Klickitat River).

2.3.1 Hydrology

Most streams in the Klickitat subbasin have natural runoff patterns, since there is no flow regulation within the watershed. Flow in the Klickitat River is primarily fed by snowmelt in spring and early summer, and by glacial melt in late spring and summer. Peak flows in the upper subbasin (upstream of Cedar Valley tributaries and some of the smaller tributaries to the north of Glenwood, e.g. Dairy and Bacon creeks) are predominantly

snowmelt-driven, although the largest events (e.g., 1996) involve rain at high elevations and rapid melting throughout the entire Klickitat subbasin (Figure 2-4). Peak flows in the middle and lower Klickitat subbasin often occur during the winter and are driven by rain-on-snow events.

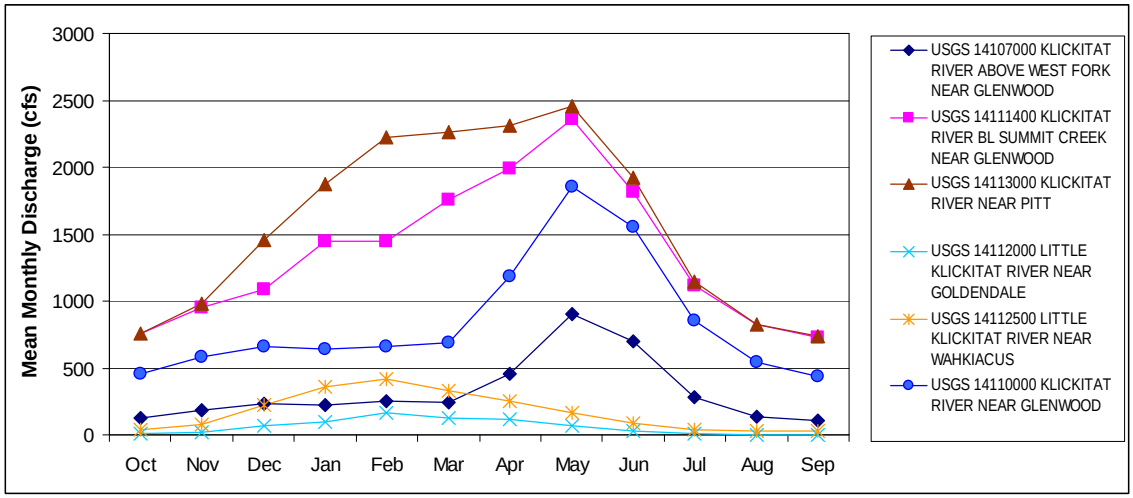


Figure 2-4. Mean Monthly Stream Flow for Six USGS-Operated Gauges on the Little Klickitat and Mainstem Klickitat rivers. (data source: USGS 2009).

The Little Klickitat River flows from the Simcoe Mountains and is largely fed by snowmelt supplemented by base flow from groundwater sources. Snow melts out of the Simcoe Mountains earlier than in the Cascade Mountains and snow pack tends to be substantially smaller. Peak flows in the Little Klickitat occur through the winter because the elevation of the watershed is within the rain-on-snow zone. The Little Klickitat River has continuous flow over nearly all of its length (Ecology 2008).

In some areas, groundwater discharge adds substantial flow to local streams. The volcanic rocks on the Mt. Adams side of the Klickitat River contain permeable volcanic debris and lava tubes. The Columbia River Basalt that underlies most of the Klickitat River Basin represents the largest source for groundwater supply within the subbasin. Cline (1976) estimates that about 60 percent of the average annual stream flow leaving the Yakama Reservation in the Klickitat River is groundwater discharge, with individual springs discharging up to 40 cubic feet/second (cfs). Springs are common in the Camas Prairie (Glenwood) area, reflecting the abundance of shallow ground water in the area (WPN and Aspect 2005a).

The middle and upper subbasin provide the vast majority of surface and ground water that contribute to mainstem baseflow. As shown in Figure 2-4, flow that supports the lower Klickitat River from July through November originates from the upper and middle Klickitat subbasin (measured at Summit Creek).

Low flow may limit steelhead production in many streams in the lower and middle Klickitat watersheds. In the lower subbasin, Swale Creek, Knight Canyon, Dillacort, Wheeler, upper Canyon, Beeks Canyon, and Dead Canyon creeks, and portions of White

Creek, dry up partially or completely in most years (WPN and Aspect 2005a). The only lower subbasin tributaries that maintain continuous or nearly continuous surface flow are the Little Klickitat River, Logging Camp Canyon and Snyder Canyon creeks, though perennial flows become restricted to middle and upper portions of Logging Camp Canyon and Snyder Creek after mid- to late-June (J. Spencer, personal communication 2006).

2.3.2 Water Quality

Water quality in the Klickitat River is influenced by natural and human factors. Glaciers on Mt. Adams, a 12,000-foot dormant volcano with an extensive glacier system, are prone to occasional outburst floods that deliver torrents of water, volcanic debris, and fine sediment via snowmelt to Big Muddy and Little Muddy creeks and the West Fork Klickitat. This results in high mainstem suspended sediment during summer months that colors the Klickitat River from the West Fork to the Columbia River, 63 miles downstream. Fine sediments associated with forestry, roads, agricultural practices, and construction may also be delivered to streams. The quantities of sediment delivered through land use practices and the effects of anthropogenic inputs have not been evaluated.

One segment of Swale Creek has been included on the Washington Department of Ecology's (WDOE's) 2008 list of impaired water bodies (303d list) because of temperature impairment (http://www.ecy.wa.gov/programs/wq/303d/2008/index.html). A water quality study was completed between June and December 2003 to assess the water temperature situation in Swale Creek and to estimate the potential and natural temperature situation in the lower portion of the creek which runs through a canyon (WPN and Aspect 2005a). The temperature criterion of 18ºC was exceeded at all stations monitored in 2003. Under current conditions, the upper two reaches of the canyon (covering roughly nine miles) are largely dry, with isolated bedrock dominated pools. In this area, shade tends to be very sparse around the pools (<25 percent). The lower three miles of Swale Creek (excluding the mouth) maintain a continuous flow during summer months with negligible volume (estimated at 0.25 to 0.5 cfs during the 2003 study; WPN and Aspect 2005a). Shade in the lower three miles approaches 100 percent effective shade in some areas. The *Klickitat River Watershed Management Plan*, developed pursuant to section 90.82 RCW, calls for an analysis to determine whether Swale Creek is appropriately categorized with respect to Washington State's surface water temperature standards, and it calls for the development and implementation of a plan to improve stream temperatures (WPN and Aspect 2005b). According to a 2002 assessment, Swale Creek has the potential to provide viable habitat for anadromous salmonids if the channel is restored and perennial water enhanced (Inter-Fluve 2002).

Several reaches in the Little Klickitat River were previously on WDOE's water quality assessment (also known as the 303(d) list) as Category 5 (i.e., impaired) for water temperature, but were reclassified to "Category 4A" (water bodies that have an approved TMDL) once the TMDL was completed for that subbasin (Brock and Stohr 2002, Anderson 2004, Ecology 2008). The TMDL and its detailed implementation plan outline actions to be taken to increase shade levels and stream flow in the Little Klickitat River

subbasin. Many of these actions are being implemented. The City of Goldendale previously relied on springs to meet water demand. Use of most of the spring facilities has been discontinued in favor of deep groundwater sources (personal communication, Dave Griffin, City of Goldendale). The Central Klickitat Conservation District (CKCD), in cooperation with area landowners, has completed tree planting along the stream in many areas (personal communication, Jim Hill CKCD). In 2006 the CKCD was awarded a grant for stream flow and temperature monitoring, riparian planting, and other actions to implement the TMDL Detailed Implementation Plan. A study completed in 2009 comparing riparian condition current canopy closure condition with historical photos found that riparian cover along the stream has been increasing over the past 30 to 40 years (Aspect and WPN 2009). The study results will serve as a baseline for future monitoring. Other actions to address the temperature issue in the stream are in progress.

2.3.3 Riparian Function and Condition

Riparian areas in most of the subbasin remain more or less intact; however, in some areas past and current timber harvest practices, roads, cattle access to riparian areas, and other localized actions have resulted in riparian corridor degradation.

In the plateau reaches, agricultural and urban land uses likely had a significant impact on the ecological functions of the riparian forest. The McCormick Meadow area of the upper Klickitat River in the tribally designated Primitive Area was heavily grazed for approximately 60 years, leaving a legacy of related problems (e.g., bank erosion, poor riparian cover, etc.). Heavy grazing in the area was terminated about 15 years ago and more recent grazing has been lighter. Riparian vegetation along Swale Creek and the Little Klickitat River has been increasing over the past 30 to 40 years (Aspect and WPN 2009). There has been no assessment of trends in riparian vegetation along the lower Klickitat River.

Reductions in beaver populations in the subbasin may have contributed to the drying and loss of some wetland and riparian habitats. Outlet Creek has been mechanically drained through the construction of ditches, but there is a natural barrier to steelhead near the mouth of the creek. It is possible that loss of wetlands in tributary headwaters in conjunction with water withdrawals may have diminished storage capacity and recharge capability. However, studies by USGS in other basins indicate that surface irrigation can increase recharge over predevelopment conditions, depending on the scale of the irrigation and other variables (Bauer and Vaccaro 1990, Vaccaro and Olsen 2007). A detailed examination of the hydrology of the Klickitat subbasin currently underway as part of implementing the WRIA 30 watershed plan will be useful for recovery planning.

2.3.4 Migration Barriers

The presence of several natural migration barriers in the Klickitat watershed may have historically limited anadromous fish production, particularly during low water years. The Klickitat River flows through a deep, steep-walled canyon with several historically impassable or marginally passable falls and cascades where the river flows over resistant bedrock. In addition, access to many of the tributaries is restricted because of impassably high gradients close to the tributary mouths. Such historical barriers were important in

maintaining separate life history strategies of *O. mykiss*, including summer steelhead, winter steelhead and resident rainbow trout.

The most significant natural barriers are the following:

- Lyle Falls (RM 2.2), a series of 5 falls from 4 to 12 feet high that historically were considered impassable during lowest water conditions in the summer and early fall (WSCC 2000). Historical data on steelhead distribution in the Klickitat subbasin are scarce; however, it is assumed that summer steelhead, like spring Chinook, were able to negotiate Lyle Falls (Bryant 1949). In 1952, Washington Department of Fisheries removed rock and constructed two fishways at the falls. Currently, Lyle Falls is not a barrier to salmon and steelhead, but passage at the natural falls is considered difficult under certain flow conditions (WSCC 2000). Planned repairs, modifications, and retrofits to the Lyle Falls Fishway will increase passage into the Klickitat subbasin.

- Castile Falls (RM 64), a series of 11 falls with an elevation drop of 80 feet over one-half mile. The falls historically presented an impediment to upstream passage of adult fish, but a 1960s attempt to improve fish passage at the falls inadvertently obstructed nearly all migration to habitat above the fishway. Recent improvements, including development of the Castile Falls Fishway, were completed in 2005 and provide steelhead and Chinook passage to the headwaters of the Klickitat. The fishway allows access to approximately 56 miles of spawning and rearing habitat in the upper mainstem and tributaries (NPCC 2004).

- Little Klickitat River Falls (RM 6.1), a 15 to 16-foot falls, restricts steelhead access to habitat areas in the upper Little Klickitat drainage. Fish passage is possible in rare cases, but these tend to be very high flow events (floods) in winter (D. Rawding, personal communication 2006). Steelhead redds above the falls were documented in 1996 and 1997, but these were years of high stream flow (WPN and Aspect 2005a). Further research is needed to obtain accurate estimates of passage frequency above the falls and steelhead spawning in the upper Little Klickitat (NPCC 2004).

- Two sets of falls on the West Fork Klickitat River — a 15 to 20-foot falls at RM 0.3 and another 15 to 20-foot falls just below the confluence of Little Muddy Creek and Fish Lake Stream at RM 4.8 — currently hinder upstream anadromous fish passage, and probably limited historical passage to upstream habitat (Thiesfeld 2001).

- A steep set of falls near the mouth of Surveyor's Creek. "The stream is impassible to salmon from the mouth upstream for about 0.8 mile. This area drops 400 feet in a series of cascades and impassable falls formed by huge slabs of rock" (LeMeir and Smith 1952).

- A 60 foot falls on Outlet Creek (RM 1.1) presents a complete barrier to all salmonids both presently and historically.

2.4 Life History Characteristics

Oncorhynchus mykiss, of which steelhead and rainbow trout are members, have a wide variety of life history strategies (Busby et al. 1996). Anadromy is not obligatory in *O. mykiss*, and the heritability of anadromy is much debated (Rounsefell 1958; Mullan et al. 1992). Progeny of anadromous steelhead can spend their entire lives in freshwater (residualize), while progeny of rainbow trout can migrate seaward. Although anadromous steelhead are the focus of interest within the Klickitat, both anadromous and resident forms are well documented in the Klickitat watershed. Resident rainbow trout are more widespread in the upper mainstem and perennial tributaries without barriers than in the lower subbasin tributaries. Anecdotal evidence, however, suggests historically wider distribution and greater population of resident *O. mykiss* in the Klickitat subbasin (B. Sharp, personal communication with YN Tribal Elders 2007).

Steelhead can be divided into two basic run types based on their level of sexual maturity at the time they enter fresh water and the duration of the spawning migration. The stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in fresh water to mature and spawn. The ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns relatively shortly after river entry (Bambrick et al. 2004).

The Klickitat River subbasin supports runs of winter and summer steelhead. Both are native to the system. Ocean-maturing or winter-run fish typically ascend streams between November and April, while summer-run, stream-maturing fish typically enter rivers between May and October. Genetic analysis shows some degree of differentiation between tributaries to the Klickitat River; genetic samples from the upper Klickitat, White Creek and Trout Creek seem to diverge most widely from the Skamania Hatchery stock (Phelps et al. 2000). Six or seven genetically distinct subpopulations have been identified within the Klickitat subbasin in recent genetic analysis (Narum et al. 2006). Analysis of genetic structure of Klickitat *O. mykiss* is ongoing. Further genetic sampling of adult native summer and winter steelhead will help identify genetic structure and enable a parentage analysis.

All winter populations in the Middle Columbia River steelhead DPS are small and unmonitored. Oregon estimates that during the early 2000s there were approximately 500 winter steelhead distributed across several small basins centered near Fifteenmile Creek. Washington populations are centered near the Klickitat. More accurate abundance estimates and productivity information are not available for winter steelhead populations in this DPS (WDFW and ODFW 2006). Little is known for certain about the small winter-run in the Klickitat (of perhaps <100 spawners), though winter steelhead appear to ascend into the river from November to April, peaking in March. Howell et al. (1985) hypothesized that winter-run fish spawned in the mainstem Klickitat from just above the confluence with the Columbia to the Little Klickitat confluence from March

through June. Recent years of observations show that mainstem steelhead spawning is concentrated between the Little Klickitat (RM 20.44) and Leidl Bridge (RM 32). It is difficult to differentiate between the spawning distributions of the two stocks.

Steelhead spawn in clear, cool streams with suitable gravel size, depth and flow velocity. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small wood. Depending on water temperature, steelhead eggs may incubate for 1.5 to four months before hatching. Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types (Bambrick et al. 2004).

Young steelhead typically rear in streams for some time before migrating to the ocean as smolts, which usually peaks in April and May in the Klickitat (Howell et al. 1985). Steelhead smolts migrate at ages ranging from 1-5 years throughout the Columbia Basin: Klickitat steelhead age composition consists of 13 percent 1-year, 83 percent 2-year and 4 percent 3-year outmigrants (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009). Some older juveniles may move downstream to rear in larger tributaries and mainstem rivers. Steelhead grow rapidly after reaching the ocean, where they forage in coastal and offshore waters of the North Pacific. Most steelhead spend two years in the ocean (range 1-4) before migrating back to their natal stream (Shapovalov and Taft 1954; Narver 1969; Ward and Slaney 1988). Once in the river, steelhead rarely eat and grow little, if at all (Maher and Larkin 1954). These combined behaviors produce fish that range between 3 and 7 years of age at the time of spawning.

Some steelhead are *iteroparous* (do not die after spawning). A small proportion of repeat spawners (known as kelts) may return to the ocean for a short period and repeat the spawning migration, a life history adaptation that may be fundamental to ensuring population stability. Respawning rates may be affected by environmental conditions, location of the natal stream, sex, size at maturity, and differences in the energy investment of spawning among different stocks and species (Fleming 1998). Winter-run fish tend to have higher respawning rates, and enter fresh water in a sexually mature state, while summer fish tend to mature sexually in fresh water (Withler 1966). Reduced genetic contributions from populations formerly supplemented by repeat spawners may contribute to the decline of steelhead stocks in the Columbia River Basin (NMFS 2000).

Iteroparity rates for Klickitat River steelhead were reported at 3.2 percent from combined sampling periods 1979 to 1981 (Howell et al. 1985) and 2005 (Yakama Nation and WDFW unpublished adult trapping data 2005). Sampling of adults at Lyle Falls Fishway in 2004 and 2005 has indicated repeat spawning rates of 2.9 percent for summer steelhead and 8.8 percent for winters. Most repeat spawners are females. Acquiring better estimates of kelt presence in the subbasin remains a priority for the Yakama Nation.

Existing data on steelhead sex ratio, age structure and frequency of re-spawning in the Klickitat subbasin is based on a sport catch sample from 1979-1981, and preliminary results from the Lyle Falls adult trap sampling and scale analysis conducted from July 2004 to October 2005 (Yakama Nation and WDFW unpublished adult trapping data 2005). Trapping efficiency and steelhead passage frequency through the ladder at Lyle Falls are still not certain, but it is likely that the sample represents only a small percentage of the total run.

During adult trap sampling and scale analysis, researchers identified adult fish as winter or summer steelhead based on a combination of observed morphological traits, in-migration timing, copepods, and scale analysis. Scales from both hatchery and wild fish were sampled and a determination of age made; however, only those fish for which there was a high level of certainty as to their run affiliation (winter or summer) were included in the demographic analysis (C. Frederiksen, personal communication 2006). Wild are identified as non-clipped adult returns into the Lyle adult trap. Skamania Hatchery summer steelhead (100 percent marked) are released as smolts into the lower Klickitat River. There are no hatchery winter steelhead releases.

Combined results from the two sampling periods show that ocean ages at return of adult summer steelhead averaged 16.7 percent 1-ocean, 72.8 percent 2-ocean, 7.3 percent 3-ocean and 3.2 percent consisting of repeat spawners (Figure 2-5). Females constituted 57.5 percent of the sample; males 42.5 percent. Figure 2-6 illustrates the length frequency distribution at ocean age of Klickitat summer-run steelhead. Trap data also suggest that hatchery steelhead have an earlier peak in migration timing than wild fish (Yakama Nation and WDFW unpublished adult trapping data 2005).

Among those fish identified as winter steelhead during the adult trapping period of 2004-2005, 1-ocean fish were predominant 47.1 percent, 2-ocean fish made up 41.2 percent of the sample, and 8.8 percent were 3-ocean fish and 8.8 percent were repeat spawners (Figure 2-7). The proportion of female to male winter steelhead was 64.5 to 35.5 percent. Due to the sampling period representing one returning brood year, ocean age structures depicted here for winter-run steelhead may not be representative of average ocean age composition (Yakama Nation and WDFW unpublished adult trapping data 2005). Figure 2-8 illustrates the length frequency distribution at ocean age of Klickitat winter-run steelhead.

Genetic analysis currently being conducted may contribute to data distinguishing the two steelhead runs in the subbasin. Sampling will continue in the future. Results of ongoing analysis will help to better differentiate the run timing between summer and winter steelhead, and provide additional data on the age structure, sex ratio and length frequency of fishing passing through the adult trap.

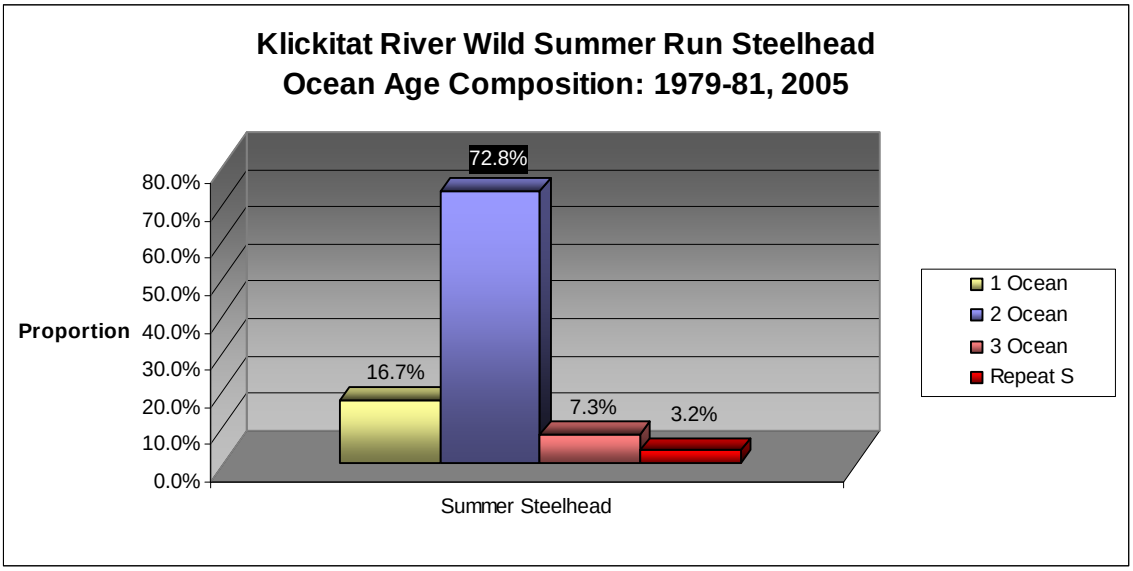


Figure 2-5. Average Ocean Age Composition of Wild Summer Steelhead in the Klickitat River, 2004-2005 (Yakama Nation and WDFW unpublished adult trapping data 2005).

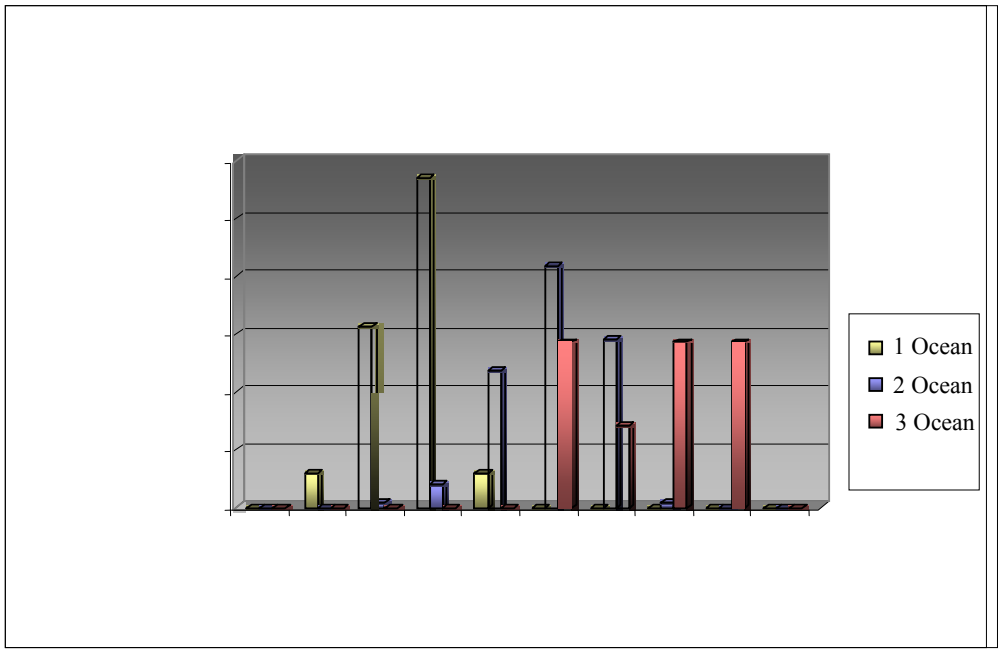


Figure 2-6. Frequency Distribution of Fork Length[2] at Ocean Age of Wild Summer Steelhead in the Klickitat River, 2004-2005 (Yakama Nation and WDFW unpublished adult trapping data 2005).

[2] Length of fish from tip of nose to fork of tail.

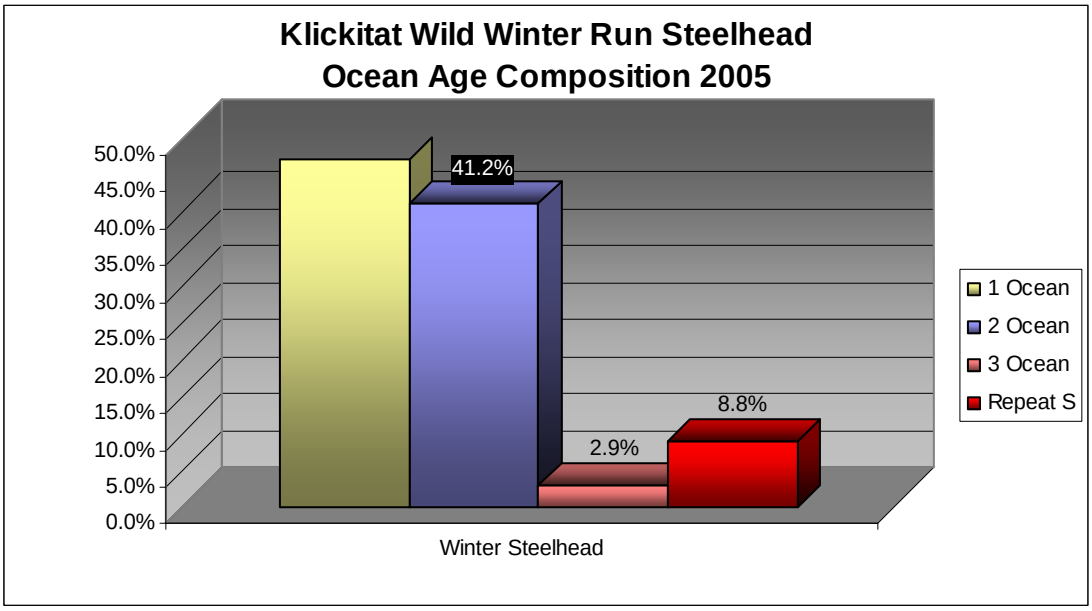
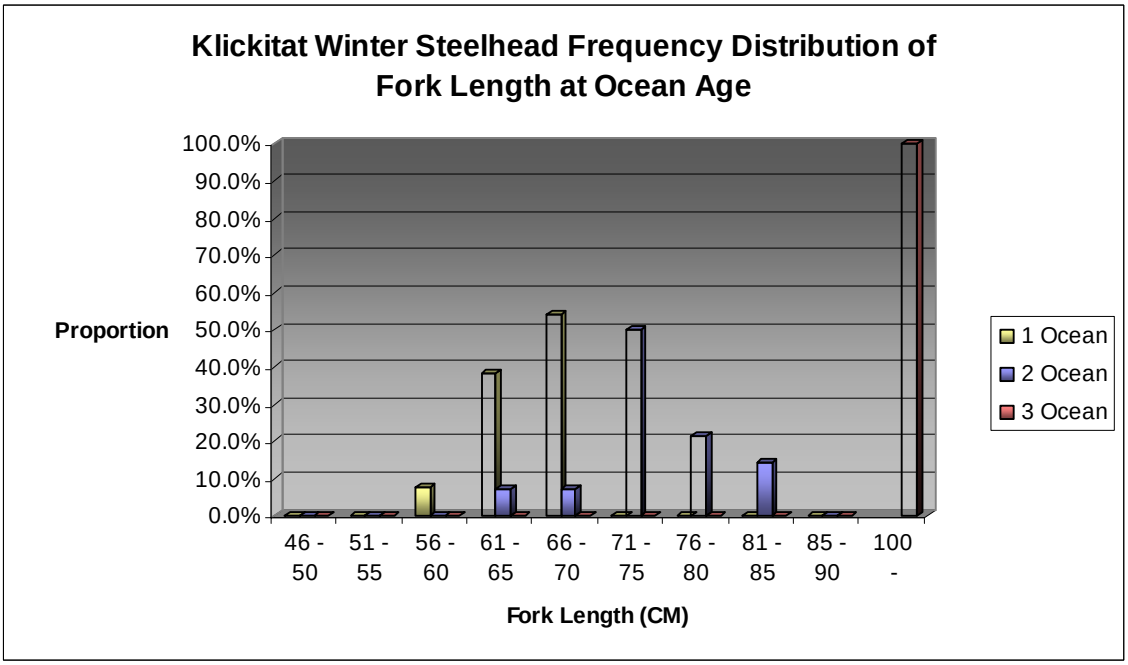


Figure 2-7. Average Ocean Age Composition of Klickitat Wild Winter-run Steelhead (Yakama Nation and WDFW unpublished adult trapping data 2005).

Figure 2-8. Frequency Distribution of Fork Length at Ocean Age of Wild Winter Steelhead in the Klickitat River, 2004-2005 (Yakama Nation and WDFW unpublished adult trapping data 2005).



***Only 1, 3-ocean wild winter steelhead was sampled, hence the abnormally high apparent proportion of fish assigned to large fork lengths.**

3. Recovery Goals and Viability Criteria

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act – i.e. to be delisted. Recovery plans may also contain "broad-sense goals," defined in the recovery planning process, that go beyond the requirements for delisting to address, for example, other legislative mandates or social, economic, and ecological values.

Delisting criteria are applied at the DPS level, and are based on determinations of the viability of the independent populations that make up the DPS. Criteria for delisting the Middle Columbia steelhead DPS are described in the *Middle Columbia Steelhead ESA Recovery Plan*, to which this plan is an appendix. This chapter provides recovery goals for the Klickitat steelhead population, describes the criteria to be used to assess progress toward those goals, and describes the role of the Klickitat steelhead population in overall DPS viability.

There are two kinds of criteria that enter into a delisting decision: population, or demographic parameters (the biological recovery criteria) and "threats" criteria related to the five listing factors detailed in the ESA. The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B) of the ESA. Both kinds of criteria are discussed in this chapter.

3.1 Recovery Goals

The primary goal of this plan is for the Klickitat steelhead population to be restored to viable status and thus to support recovery of the Mid-Columbia steelhead DPS. A viable salmonid population is defined as an independent population that has negligible risk of extinction over a 100-year timeframe (McElhany et al. 2000).

If a local, collaborative Washington Gorge Recovery Board is formed, it may choose to define additional, broad-sense goals for the Klickitat subbasin and other areas within the Washington Gorge Management Unit. The Board's broad-sense goals for the area would likely build on direction, and respond to the interests identified by various stakeholders in the area. These goals would then guide the Board as it defines and implements future recovery actions for the Klickitat subbasin.

In the meantime, the Yakama Nation has proposed, as a broad-sense goal for the Klickitat steelhead population, the achievement of "highly viable" status, which corresponds to a one percent risk of extinction in a 100-year period. Achieving highly viable status for the population would provide for long-term, sustainable harvest and other social, cultural, and ceremonial needs, although it would likely exceed the minimum necessary to support delisting the DPS.

3.2 Biological Viability Criteria

The ICTRT developed biologically based viability criteria for ESA-listed salmon and steelhead in the Interior Columbia domain. The ICTRT based its approach to recovery on guidance from the NMFS Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). This memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels.

Viability criteria at the population level address four VSP parameters (McElhany et al. 2000):

- *Abundance* – the average number of spawners in a population over a generation or more,
- *Productivity* – the performance of a population over time in terms of recruits produced per spawner,
- *Spatial Structure* – a population's geographic distribution and the processes that affect that distribution, and
- *Diversity* – the distribution of genetic, life history and phenotypic variation within and among populations.

The ICTRT grouped specific population level criteria into two categories to assess viability at the independent population level: measures addressing abundance and productivity, and measures addressing spatial structure and diversity. The viability of an independent population is determined by integrating risks across the four parameters.

3.2.1 DPS and MPG Viability Criteria

Since MPGs are geographically and genetically cohesive groups of populations, they are critical components of ESU/DPS spatial structure and diversity. Having all MPGs within an ESU/DPS at low risk provides the greatest probability of persistence for the ESU/DPS. Thus, the ICTRT criterion for a viable ESU/DPS is that all extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS should be at low risk.

Further, the following five criteria should be met for an MPG to be regarded as low risk (viable) (ICTRT 2007):

1. At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.

2. At least one population should be classified as "Highly Viable."

3. Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as "Very Large," "Large," or "Intermediate," generally reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.

4. All major life history strategies (e.g. spring and summer run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.

5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU/DPS recovery.

3.2.2 Application of Biological Viability Criteria to Klickitat Population

The ICTRT classified the Klickitat steelhead population as an "Intermediate" sized population based on historical habitat potential (ICTRT 2007).

Applying the ICTRT's viability criteria to the Cascades Eastern Slope Tributaries MPG results in the conclusion that the Klickitat steelhead population should reach viable status in order to support overall DPS viability, because of the population's historical abundance and the presence of both summer and winter runs.

Abundance
For an Intermediate population, viable status, i.e. a 5 percent or less risk of extinction over a 100-year timeframe, would require a mean minimum abundance threshold of 1,000 naturally produced spawners.

Productivity
Viable populations demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels.

Spatial Structure and Diversity
The ICTRT identified six major spawning areas (MaSAs) and four minor spawning areas (MiSAs) within the Klickitat population boundaries based on its historical intrinsic potential analysis. The analysis indicated that the upper mainstem Klickitat watershed was once a highly productive steelhead spawning area.

In general, the ICTRT defined two goals, or biological or ecological objectives, that spatial structure and diversity criteria should achieve:

- Maintaining natural rates and levels of spatially mediated processes. This goal serves (1) to minimize the likelihood that populations will be lost due to local catastrophe, (2) to maintain natural rates of recolonization within the population and between populations, and (3) to maintain other population functions that depend on the spatial arrangement of the population.

- Maintaining natural patterns of variation. This goal serves to ensure that populations can withstand environmental variation in the short and long terms. (ICTRT 2007, p. 47).

Data on Klickitat steelhead are limited. The primary factors contributing the moderate risk designation in the ICTRT (2009) viability assessment were related to lack of information on: a) the population's abundance and productivity, and, b) the effects of hatchery operations on the population. One of the primary goals of the Klickitat recovery plan is to attain the information needed to address these uncertainties.

3.3 Threats Criteria

Listing factors are those features that were evaluated under section 4(a)(1) when the initial determination was made to list the species for protection under the ESA. These may or may not still be limiting recovery when in the future NMFS reevaluates the status of the species to determine whether the protections of the ESA are no longer warranted and the species could be delisted.

At the time of a delisting decision, NMFS will examine whether the section 4(a)(1) listing factors have been addressed. To assist in this examination, NMFS will use the listing factors (or threats) criteria described below in addition to evaluation of biological recovery criteria and other relevant data and policy considerations.

To determine that the affected DPS is recovered to the point that it no longer requires the protections of the ESA, NMFS will review the status of the listing factors according to the specific criteria identified for each of them. The threats need to have been addressed to the point that delisting is not likely to result in their re-emergence. It is possible that current perceived threats will become insignificant in the future because of changes in the natural environment or changes in the way threats affect the entire life cycle of salmon. Consequently, NMFS expects that the ranking of threats will change over time and that new threats may be identified. During the status reviews, NMFS will evaluate and review the listing factor criteria under conditions at the time.

The specific criteria listed below for each of the relevant listing/delisting factors helps to ensure that underlying causes of decline have been addressed and mitigated prior to considering a species for delisting. NMFS anticipates that if the proposed actions described in the Plan are implemented, they will make substantial progress toward meeting the following listing factor (threats) criteria:

Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range

To determine that the DPS is recovered, threats to habitat should be addressed to a degree sufficient to support a viable Middle Columbia River steelhead DPS as outlined below:

1. Impaired fish passage (e.g., dams and culverts) is addressed, either through removal or modification of obstructions, to improve survival and restore access to historically accessible habitat where necessary to support recovery goals.
2. Flow conditions that support sufficient steelhead rearing, spawning, and migration of a viable DPS are achieved, where possible, through management of mainstem and

tributary irrigation and hydropower operations, and through the improvement of other water user efficiencies and conservation, including for municipal supply and other consumptive purposes.

3. Forest management practices that protect watershed and stream functions are implemented on Federal, state, tribal, and private lands.
4. Agricultural practices, including grazing, are implemented to protect and restore riparian areas, floodplains, and stream channels, and to protect water quality from sediment, pesticide, herbicide, and fertilizer runoff.
5. Urban and rural development, including land use conversion from agriculture and forestland to residential uses, avoids impairment of water quality or impair natural stream conditions.
6. The effects of toxic contaminants on salmonid fitness and survival in the mainstem and tributaries are sufficiently limited so as not to affect recovery.
7. Channel function, including vegetated riparian areas, canopy cover, stream-bank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity is restored to provide adequate rearing and spawning habitat.
8. Floodplain function and the availability of floodplain habitats for salmon are restored to a degree sufficient to support a viable DPS. This restoration should include connectivity between river and floodplain and the restoration of altered sediment routing.
9. Water operations management in the mainstem and tributaries maximize survival of juvenile rearing, emigrating smolts, and immigrating and spawning adults.

Factor B: Over-utilization for commercial, recreational, scientific or educational purposes

To determine that the DPS is recovered, any utilization for commercial, recreational, scientific, or educational purposes should be managed as outlined below:

1. Fishery management plans for steelhead are in place that (a) accurately account for total fishery mortality (i.e., both landed catch and non-landed mortalities) and constrain mortality rates to levels that are consistent with achieving population viability (i.e., provide for adequate spawning escapement given their productivity); and (b) are implemented in such a way as to avoid deleterious genetic effects on populations or negatively affect the distribution of populations.
2. Federal, state and tribal fishing rules and regulations are effectively enforced.
3. Technical tools accurately assess the effects of the harvest regimes so that harvest objectives are met but not exceeded.
4. Scientific handling of fish from adult and juvenile trapping operations is minimized to reduce indirect mortalities associated with education or scientific programs, while

recognizing that monitoring, research, and education are key actions for conservation of the species.

5. To the degree sufficient to support a viable DPS, routine instream construction and maintenance practices are implemented in a manner to reduce or eliminate mortality of listed species.

Factor C: Disease or predation

To determine that the DPS is recovered, any disease or predation that threatens its continued existence should be addressed as outlined below:

1. Hatchery operations do not subject steelhead populations to deleterious diseases and parasites and do not result in increased predation rates of wild steelhead.
2. Predation by avian predators is managed in a way that promotes recovery of salmon and steelhead populations.
3. The northern pikeminnow are managed to reduce predation on steelhead to a degree sufficient to meet recovery goals.
4. Populations of introduced smallmouth bass, walleye, and catfish are managed such that competition or predation does not impede steelhead recovery.
5. Predation by marine mammals on steelhead runs below Bonneville Dam is managed within the framework of applicable statutes and to the degree necessary to protect upstream migration of steelhead.

Physiological stress and physical injury that may cause disease or increase susceptibility to pathogens during rearing or migration should be reduced during critical low flow periods (e.g. low water years) or poor passage conditions (e.g. at diversion dams or bypasses).

Factor D: The inadequacy of existing regulatory mechanisms

To determine that the DPS is recovered, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be addressed to the degree necessary to support a viable DPS, as outlined below:

1. Sufficient resources, priorities, regulatory frameworks, and coordination mechanisms are established and/or maintained for effective enforcement of land and water use regulations that protect and restore habitats and for the effective management of fisheries.
2. Habitat conditions and watershed functions are protected through land-use planning that guides human population growth and development.
3. Habitat conditions and watershed function are protected through regulations that govern resource extraction such as timber harvest and gravel mining.

4. Habitat conditions and watershed functions are protected through land protection agreements as appropriate, where existing policy or regulations do not provide adequate protection.

5. Regulatory, control, and education measures to prevent additional exotic plant and animal species invasions are in place.

Factor E: Other natural or human-made factors affecting its continued existence

To determine that the DPS is recovered, other natural and human-made threats to its continued existence should be addressed as outlined below:

1. Steelhead hatchery programs are being operated in a manner that is consistent with individual watershed and region-wide recovery approaches; appropriate criteria should be used for the integration of hatchery steelhead populations and extant natural populations inhabiting watersheds where the hatchery fish return.

2. Hatcheries operate using appropriate ecological, genetic, and demographic risk containment measures for (1) hatchery-origin adults returning to natural spawning areas, (2) release of hatchery juveniles, (3) handling of natural-origin adults at hatchery facilities, (4) withdrawal of water for hatchery use, (5) discharge of hatchery effluent, and (6) maintenance of fish health during their propagation in the hatchery.

3. Mechanisms are in place to effectively continue monitoring the proportion of hatchery and wild spawners in the subbasin.

4. Mechanisms are in place to reduce the incidence of, and impacts from, introduced, invasive, or exotic plant and animal species.

5. Nutrient enrichment programs should be evaluated to determine where additional nutrient inputs can provide significant benefits.

4. Current Status Assessment

There are currently neither solid historical data nor accurate metrics for assessing current status of the Klickitat steelhead population. The first priority for recovery planning for this population is to reduce the uncertainties with a targeted monitoring program (see Chapter 6, Recovery Strategy and Actions, and Chapter 8, Monitoring, Research, and Adaptive Management).

The ICTRT reviewed existing data, previous assessment findings and GIS analysis for its 2005 viability assessment of the Klickitat population. This work has been updated by the ICTRT (2009). The Yakama Nation staff biologists provided substantial additional data, summarized in this chapter, which is, however, of a relatively short generational span and limited by significant uncertainties.

The ICTRT viability assessment is presented first, followed by currently available status information from the Yakama Nation. Discussion is also provided of ICTRT, Yakama Nation, and Klickitat County findings regarding identification of major and minor spawning areas.

4.1 ICTRT Status Assessment

4.1.1 Major and Minor Spawning Areas

The ICTRT identified major and minor spawning areas in the Klickitat system using model results that estimated the historical amount of potentially accessible spawning and rearing habitat available to the specific population based on stream width, gradient, and valley width from GIS-based analysis of tributary habitat associated with each population (ICTRT 2007). This historical intrinsic potential analysis conducted by the ICTRT identified six major spawning areas (MaSAs) and four minor spawning areas (MiSAs) within the Klickitat population boundaries (Figure 4-1). The ICTRT defines a major spawning area as a system of one or more branches that contains sufficient historical intrinsic habitat potential to support at least 500 spawners. This structure is typical of intermediate or large drainages. The ICTRT defines minor spawning areas as contiguous production areas capable of supporting between 50 and 500 spawners. The ICTRT does not consider any population fewer than 500 spawners to be viable, regardless of its intrinsic productivity (ICTRT 2007).

Major spawning areas identified by the ICTRT in the Klickitat drainage are the Upper Mainstem Klickitat, White River, Upper Little Klickitat, Lower Mainstem Klickitat, Middle Mainstem Klickitat and West Fork Klickitat MaSAs. Minor spawning areas are the Swale Creek, Lower Little Klickitat, Trout Creek and Surveyors Creek MiSAs. Middle Columbia steelhead occupy all major spawning areas in the Klickitat drainage with the exception of the West Fork Klickitat MaSA.

There is a high degree of correlation between the assessment areas used in the Klickitat River subbasin plan (NPCC 2004) and the areas identified using the ICTRT intrinsic potential analysis. In addition, the ICTRT analysis was modified based on input from regional biologists to identify reaches in the Little Klickitat drainage and MaSAs that are inaccessible under some annual flow conditions.

Yakama Nation Fisheries staff noted that several tributaries identified by the ICTRT as having high intrinsic habitat potential differ in various aspects from Yakama Nation resource specialists' understanding of the areas (see Figure 4-2). For example, there are discrepancies between a few headwater tributaries such as Sheep and Blue creeks. Sections of Swale, Big Muddy, and Hellroaring creeks, upper Knight and Wide Sky canyons and other creeks are included by the ICTRT as having segments of high intrinsic historical potential for steelhead spawning habitat, although Yakama Nation staff consider it highly improbable that the segments were even historically conducive to spawning, because of geomorphological and biotic factors. Yakama Nation staff also contend that historical spawning distribution of steelhead in Trout Creek and the Little Klickitat River was unlikely to have extended as far upstream as the ICTRT's GIS model indicates. The Yakama Nation Fisheries staff delineated 11 spawning areas in the Klickitat watershed, based on EDT analysis, that they believe better reflect spawning habitat areas for the steelhead population. Appendix III discusses these areas and compares them to the areas identified by the ICTRT.

Klickitat County staff agree that the distribution of steelhead in the Little Klickitat is unlikely to extend as far upstream as the ICTRT's GIS model indicates. They believe that fish distribution in the Little Klickitat stops at the falls at RM 6.1, except in rare years when some minor passage may occur under certain unusual flow conditions. They note that the ICTRT's estimate of fish distribution in Swale Creek is also over-represented, and that during summer and fall steelhead are found only in the lower three miles where there is water (WPN and Aspect 2005a).

Despite these differences between GIS data and hardcopy maps, the basic patterns of predicted and observed occupancy of the subbasin are similar. Because the intrinsic potential model incorporates broad scale landscape and hydrological variables, subbasin specific characteristics often cause local differences between observations, professional knowledge, and modeled predictions of pre-development habitat conditions. However, using the ICTRT's habitat branching and MaSA/MiSA accumulation methods, these disparities are generally insignificant at the MaSA/MiSA scale. Many of the tributaries mentioned above contain well below one percent of the total intrinsic habitat modeled within the Klickitat population.

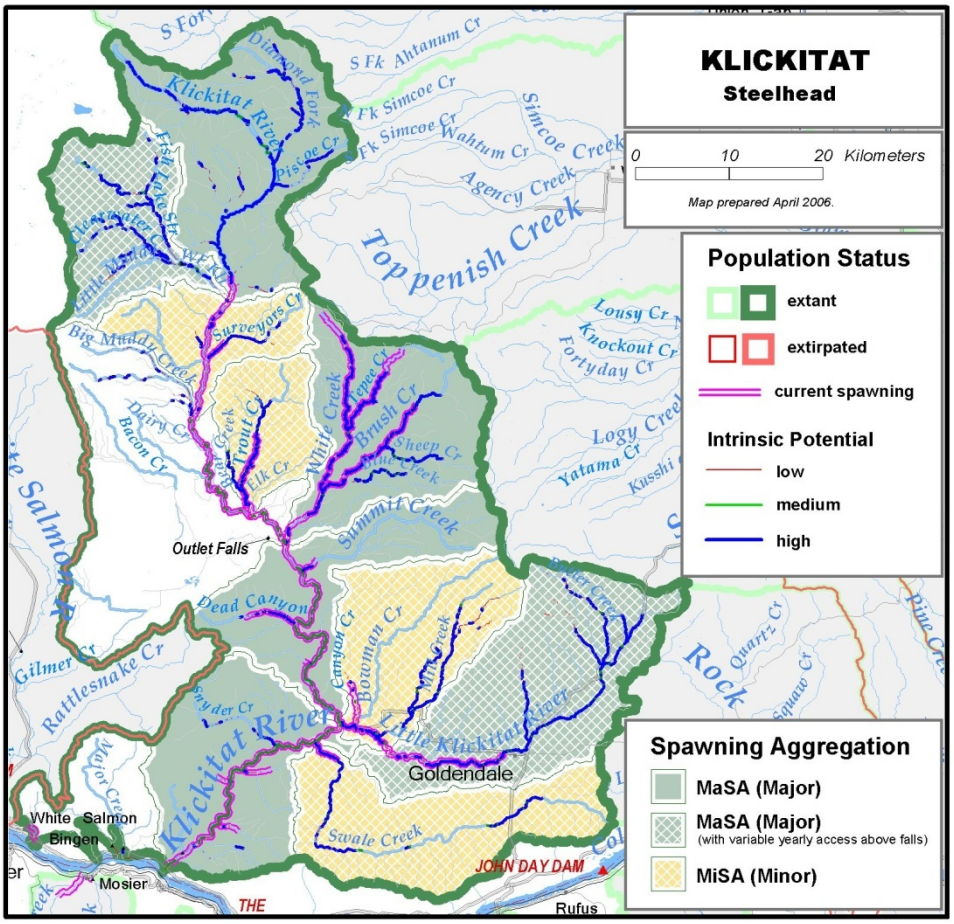


Figure 4-1. Klickitat River Steelhead population boundary and historical major and minor spawning areas (ICTRT 2007).

4.1.2 Abundance and Productivity

The ICTRT (2009) found that annual estimates of the total number of steelhead spawning in the Klickitat River drainage prior to the 2005-2006 return year have not been generated. Redd surveys of steelhead spawning in the Klickitat River drainage have been conducted in recent years, but there is insufficient coverage to allow for directly estimating annual abundance from those samples.

Separate estimates of the escapement of hatchery-origin and natural-origin steelhead past Lyle Falls have been generated for the 2005-2006 return year using mark-recapture methods (Gray 2007). An estimated 1,577 natural-origin and 1,833 hatchery-origin adult steelhead were estimated to have passed above Lyle Falls and the associated tribal fishery in that return year. Returns to the Klickitat River include hatchery-origin adults from annual out-plants of Skamania Hatchery summer steelhead from North Fork Washougal River broodstock (approximately 100,000 smolts per year) into the middle sections of the mainstem Klickitat River. A hatchery-directed sport fishery has harvested an estimated 1,400 to 3,700 fish per year between 2000 and 2004 (http://wdfw.wa.gov/fish/papers/steelhead/m_col_esu.pdf). The estimated returns above Lyle Falls would be reduced by hatchery sport harvest (direct catch of hatchery,

incidental mortalities of natural-origin fish), potential fall back and any pre-spawning mortalities.

Assuming that annual estimates of the number of steelhead passing Lyle Falls continue to be generated, after a sufficient number of estimates are accumulated, it may be possible to use a derived relationship between index area redd counts and total abundance to extend annual estimates back using the recent historical redd counts.

Determining the relative distribution of hatchery and natural-origin spawners on the spawning grounds would reduce uncertainty with generating productivity estimates from the return series. Estimated abundance and harvest data provided by the Yakama Nation are included as Appendix IV.

The ICTRT was able to assign a size category to the Klickitat steelhead population based on historical intrinsic potential analysis. Size categories reflect drainage complexity and the distribution of current and historical spawning habitat. Upstream limits on the potential use of tributary habitat for spawning and rearing were defined in terms of physical barriers, stream gradient, width, and water temperature, on the basis of multiple sources, including GIS data, published accounts, field personnel, and local expert review. The ICTRT considers the Klickitat River population to be an "intermediate" sized population. To be considered viable, i.e. having a 5 percent or less risk of extinction over a 100-year timeframe, an intermediate-sized population should have a mean minimum abundance of 1,000 naturally produced spawners.

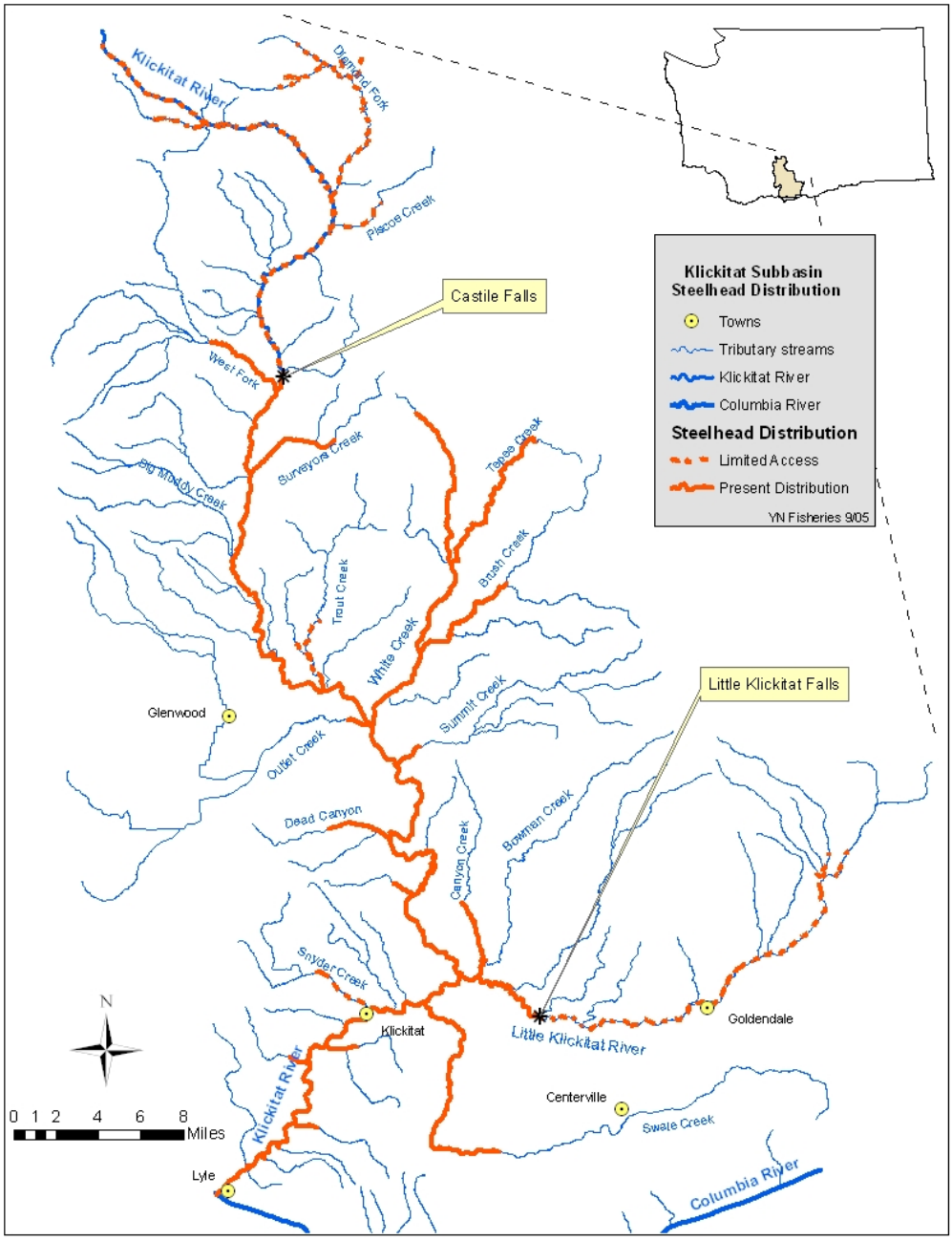
Because of insufficient data and the uncertainties regarding naturally occurring production, the ICTRT provisionally assigned the Klickitat River population **Moderate risk** for abundance and productivity (ICTRT 2007).

4.1.3 Spatial Structure and Diversity

Current steelhead spawning in the Klickitat mainstem is concentrated between RM 5 and RM 50, with occasional spawning above Castile Falls (RM 64). Figure 4-2 shows current steelhead distribution in the Klickitat subbasin, with areas of "limited access," as inferred based on restrictions in passage conditions, represented by dashed lines. Tributary spawning currently occurs in the White Creek watershed (including Tepee and Brush creeks), Dead Canyon, Swale Canyon, Wheeler, Summit, and lower Bowman creeks, the lower (and occasionally upper) Little Klickitat River, and other smaller tributaries.

Winter steelhead are believed to spawn between the confluence of the Klickitat with the Columbia River and the confluence of the Little Klickitat with the mainstem (Howell et al. 1985). Further research on spawning distribution of winter steelhead in the Klickitat subbasin is needed. Steelhead distribution, however, is expected to extend into the upper watershed in the near future because passage for anadromous fish at Castile Falls has recently been restored and the upper subbasin is now re-connected.

Figure 4-2. Summer and Winter Steelhead Distribution in the Klickitat Subbasin (NPCC 2004).



Based on its historical intrinsic potential analysis, the ICTRT identified six major spawning areas (MaSAs) (systems of one or more branches capable of supporting 500 spawners), and four minor spawning areas (MiSAs) (able to support between 50 and 500 spawners) within the Klickitat population boundaries (ICTRT 2007) (Table 4-1 and Figure 4-3). The analysis assumed that the upper mainstem Klickitat watershed was once a highly productive steelhead spawning area.

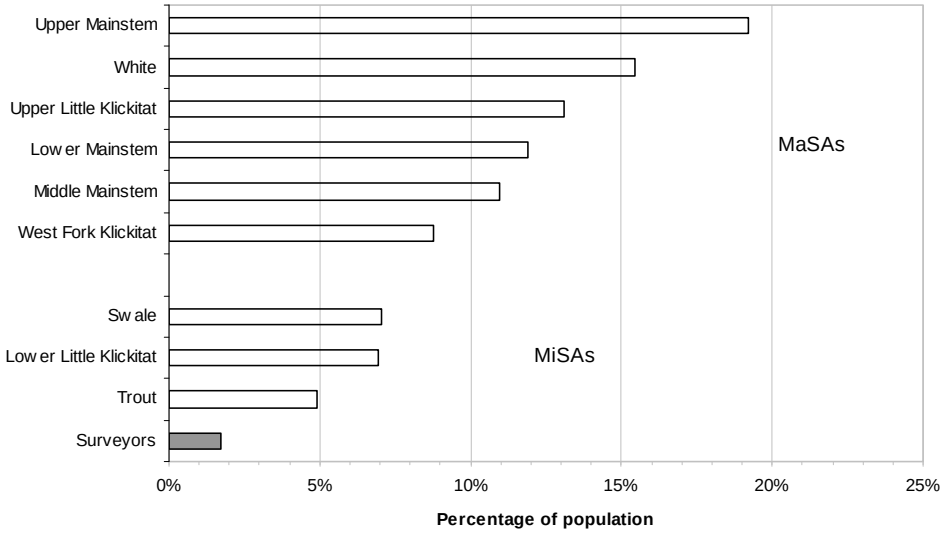
Table 4-1. Klickitat Summer/Winter Steelhead population basin statistics and intrinsic potential analysis summary (ICTRT 2009).

Drainage Area (km^2)	**3,632**
Stream lengths km[a] (total)	**2,590**
Stream lengths km[a] (below natural barriers)	**1,701**
Branched stream area weighted by intrinsic potential (km2)	**2.978**
Branched stream area km2 (weighted and temp. limited)[b]	**2.978**
Total stream area weighted by intrinsic potential (km2)	**3.990**
Total stream area weighted by intrinsic potential (km2) temp limited[b]	**3.990**
Size and Complexity category	**Intermediate / B (dendritic)**
Number of MaSAs	**6**
Number of MiSAs	**4**

[a]All stream segments greater than or equal to 3.8m bankfull width were included

[b]Temperature limited areas were assessed by subtracting area with mean weekly modeled water temperature greater than 22ºC

Figure 4-3. Percentage of Historical Spawning Habitat by Major/Minor Spawning Area. (ICTRT 2009).



Genetic samples from different areas within the Klickitat River system cluster together but appear to be relatively homogeneous. Compared to other populations, the Klickitat subpopulation samples cluster together. The closest association is with the Skamania Hatchery stock; the level of differentiation suggests a common origin. The ICTRT rated the Klickitat steelhead population as at **Moderate risk** for this metric (ICTRT 2009).

The ICTRT rated the Klickitat River steelhead population at **Moderate risk** for spatial structure and diversity based on an assessment of the cumulative scores across the individual spatial structure/diversity factors and metrics (Table 4-2). It determined that reducing the spatial structure/diversity risk to a low rating would require reducing the impacts of the outside stock hatchery program on natural spawning areas, or determining that the natural population is actually experiencing very little impact from the Skamania stock origin returns.

Table 4-2 summarizes ICTRT viability assessment results for Klickitat steelhead population spatial structure and diversity factors and metrics. Table 4-3 shows the ICTRT's spatial structure and diversity scoring table for the population.

Table 4-2. ICTRT viability assessment results for Klickitat steelhead population spatial structure and diversity factors and metrics (ICTRT 2009).

Factors and Metrics	Risk Rating	ICTRT Comments
A.1.a. Number and spatial arrangement of spawning areas.	Low	All six of MaSAs inferred as occupied based on the WDFW and YN data. More data needed to confirm current distribution information.
A.l.b. Spatial extent or range of population.	Low	Intrinsic potential approach assumes that steelhead had access to the upper Klickitat (mainstem and tributaries above Castile Falls) and the upper sections of the Little Klickitat River. Historical access to the upper Klickitat may have been limited by Castile Falls. WDFW and YN data indicate that all MaSAs and MiSAs are currently occupied. Distributions should be confirmed through systematic ground surveys.
A.1.c. Increase or decrease in gaps or continuities between spawning areas	Low	The WDFW current distributions and the YN redd survey data sets indicate that the lower most MaSAs are at least partially occupied and there is a presence of steelhead spawners in the MiSAs below the Little Klickitat River. There are no intervening gaps among the occupied MaSAs in the Klickitat.
B.1.a. Major life history strategies	Low	There is no evidence of loss of a major juvenile life history pattern.
B.1.b. Phenotypic variation.	Moderate	It is possible that continual inputs of outside hatchery-origin spawners (Skamania stock) have altered spawning timing and other phenotypic characteristics of the native run. Rating is precautionary given absence of more specific information on the relative contributions of hatchery spawners to natural spawners.
B.1.c. Genetic variation.	Moderate	Genetic samples from different areas within the Klickitat River system cluster together but appear to be relatively homogeneous. Compared to other populations, the Klickitat subpopulation samples cluster together. The closest association is with the Skamania Hatchery stock; the level of differentiation suggests a common origin.
B.2.a. Spawner composition.	High	No systematic sampling studies have been done to determine the relative contribution of returns from the hatchery releases in the Klickitat to natural spawning areas. The only reported information on relative hatchery wild composition for the Klickitat are results of sport catch sampling efforts in the late 1980s, indicating that up to 2/3 of the catch were hatchery-origin. It is possible that those estimates reflect the contribution rates in the lower Klickitat and are not directly representative of hatchery contribution rates to spawning in the majority of natural production areas. Based on release levels and sport catch estimates, it is very likely that the hatchery contribution rate to natural spawning has exceeded 5 percent for more than 4 generations. Rating reflects the absence of direct information confirming differential spawning distribution of hatchery and natural fish and/or information on relative contribution rates to natural spawning areas.
B.3.a. Distribution of population across habitat types	Low	Current spawning distribution (WDFW GIS layer and YN fisheries redd survey results) indicates occupied MaSAs cover three of the four historical regions. Current and historical ecoregion ratios need to be checked (specifically the relative contribution of the Grand Fir Mixed Forest).
B.4.a. Selective change in natural processes or selective impacts.	Low	Low risk estimates given across the four sectors: hydropower system, harvest, hatcheries, habitat.

Table 4-3. Spatial Structure and Diversity Scoring Table: Klickitat Steelhead Population (ICTRT 2009).

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	L (1)	L (1)	Mean = 1.25 Low Risk	Low Risk	**Moderate Risk**
A.1.b	L (1)	L (1)			
A.1.c	L (1)	L (1)			
B.1.a	L (1)	L (1)	Moderate Risk	Moderate Risk	
B.1.b	M (0)	M (0)			
B.1.c	M (0)	M (0)			
B.2.a(1)	H (-1)	High Risk (-1)	High Risk (-1)		
B.2.a(2)	NA				
B.2.a(3)	NA				
B.2.a(4)	NA				
B.3.a	L (1)	L (1)	L (1)		
B.4.a	L (1)	L (1)	L (1)		

4.1.4 Overall Risk Rating

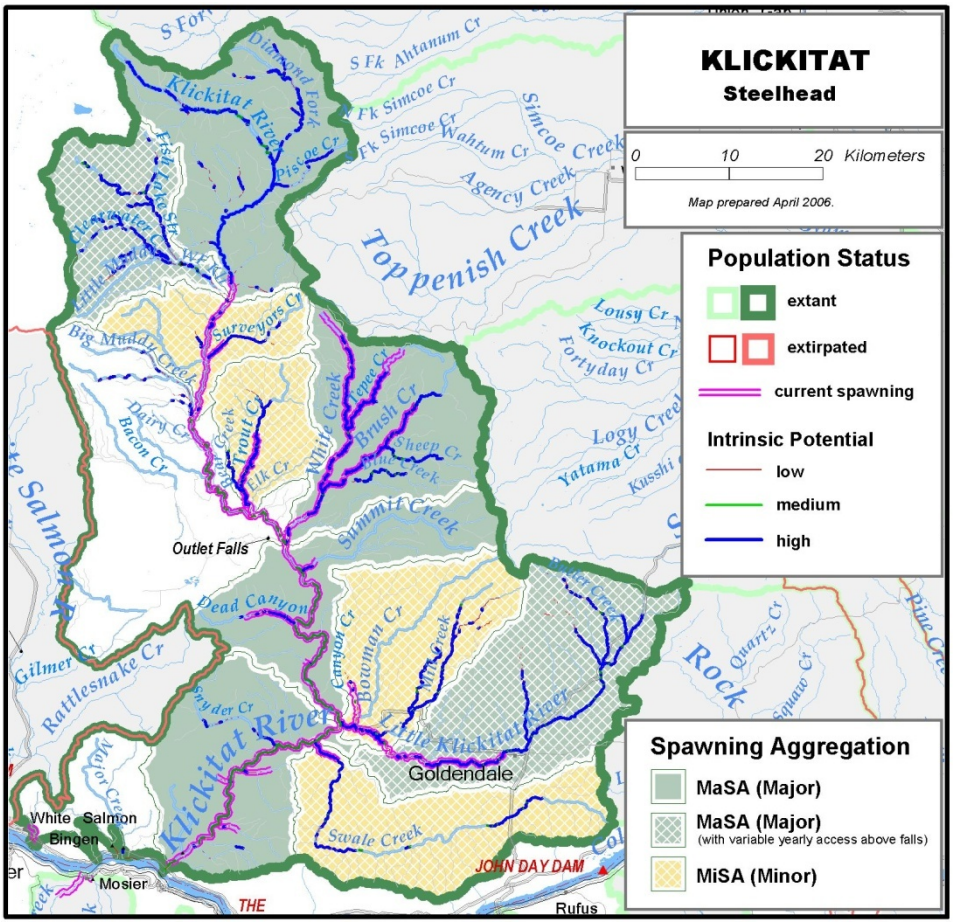
The ICTRT rated the Klickitat River steelhead population at **Moderate risk** of extinction in one hundred years for both abundance/productivity and spatial structure/diversity. Thus, the population does not meet the criteria for a viable population as defined by the ICTRT (ICTRT 2007). Figure 4-4 is a matrix that illustrates the combinations of risk levels for all four VSP parameters that define low, moderate, and high risk ratings for a population or DPS. "Viable" status is defined as having no more than a 5 percent likelihood of extinction within 100 years. Moderate risk corresponds to "maintained" status, which designates a population that can contribute to overall DPS viability by providing ecological functions and preserving options for recovery. Maintained populations can serve as buffers against catastrophic losses to other, more viable populations and/or uncertainty in the ICTRT population and MPG criteria. Ensuring that the less than viable populations meet maintained standards reduces the risk for the MPG. However, as previously noted, the Klickitat population has characteristics that are sufficiently important to the DPS to make it an appropriate candidate for viable status.

The ICTRT noted that developing a method for generating annual estimates of natural contributions to spawning in the Klickitat would allow for a more accurate assessment of both abundance and productivity. With respect to spatial structure and diversity, the population would benefit from actions that promote or confirm a high level of separation between hatchery-origin spawners and natural production. More detailed evaluations of

genetic patterns within the population, and of the range of life history variations present in the population, could also contribute to improving the status level assigned through application of the ICTRT criteria.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M Klickitat River***	**HR**
	High (>25%)	**HR**	**HR**	**HR**	**HR**

Figure 4-4. Viable Salmonid Population Parameter Risk Ratings for the Klickitat River Steelhead Salmon Population (ICTRT 2009). ***Viability Key: HV – Highly Viable; V – Viable; M – Maintained; HR – High Risk; * = Candidate for Maintained; Shaded cells – does not meet viability criteria (darkest cells are at greatest risk).***



5. Limiting Factors and Threats

The reasons for a species' decline are generally described in terms of limiting factors and threats. Analysis of limiting factors and threats across the entire species' life cycle forms the basis for designing recovery strategies and actions. NMFS defines limiting factors as the biological and physical conditions limiting DPS and population status (e.g. elevated water temperature), and defines threats as those human activities or naturally induced actions that cause the limiting factors (e.g. removal of riparian vegetation for agricultural or residential purposes, which causes loss of shade and, consequently, elevated water temperature).

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are often legitimate human activities that may at times have unintended negative consequences on fish populations—and that can usually be managed in a manner that minimizes or eliminates the negative impacts.

For steelhead and other salmonids, survival to reproduce depends on a complex, interacting system of environmental conditions, with different conditions needed for each life stage. Optimal water temperature, for example, varies (within limits) for adult migration vs. egg incubation or juvenile rearing. In addition, the particular factors limiting production may vary across different sections of the tributary drainage used by a particular population. Data on a full range of potential limiting factors is rarely available at the reach level. As a result, the identification of limiting factors for salmonids often includes elements based on inference and expert opinion.

The list of potential limiting factors for the Klickitat steelhead population, as for the other populations that make up the DPS, is based on a substantial body of research on salmonids, local field data and field observations, and the considered opinions of regional experts. These are implicitly hypothetical statements, made with the expectation that by taking action in the face of some degree of scientific uncertainty, monitoring the results, continuing to conduct research as a high priority, and adapting our management actions in response, the state of our knowledge will improve and so will the survival of these fish, although not necessarily in a directly parallel process. In that spirit, this chapter describes the factors, based on the best available science, considered to be limiting Middle Columbia River steelhead production in the Klickitat subbasin.

5.1 Hatchery Effects

Uncertainty regarding the effects of hatchery releases on the naturally spawning population is one of the two primary reasons the ICTRT rated the Klickitat steelhead population as at moderate risk (the other factor is the lack of information regarding abundance) (ICTRT 2009). Hatchery releases and interactions between hatchery and wild fish are likely to have a significant impact on the viability and productivity of the naturally spawning population.

Hatchery-bred smolts from the Skamania and Vancouver hatcheries have been released into the Klickitat River for nearly 40 years. Releases were also made from the Beaver Creek and Naches hatcheries. Releases have averaged approximately 102,000 smolts annually since 1982, ranging from 16,000 smolts in 1995 to 118,500 smolts in 2000. The current hatchery steelhead production goal for the Klickitat subbasin is an annual release of 120,000 summer-run steelhead from Skamania and Vancouver hatcheries directly into the Klickitat River. Both hatcheries use Skamania Hatchery broodstock, which is maintained using steelhead returning to the Skamania Hatchery on the Washougal River. The broodstock for the program was originally established with wild fish taken from both the Washougal and Klickitat River systems. To limit adverse interactions with naturally produced juvenile steelhead, hatchery summer steelhead are released at times and sizes that result in rapid emigration from the subbasin. The releases occur in the mainstem Klickitat River below the primary upstream spawning and rearing areas.

Skamania summer steelhead releases in the Klickitat River mainly provide for sport fisheries in the river (Bosch et al. 2004). Hatchery-reared winter steelhead have never been released in the Klickitat subbasin (Sharp 2000).

Currently there is insufficient information to determine the effects of hatchery releases on the natural steelhead population. While it is likely that hatchery hybridization of Skamania stock with wild steelhead has occurred in the Klickitat subbasin (NPCC 2004), the level of impact on the natural population remains uncertain. In its recent viability assessment for the population, the ICTRT (2007) found that the only reported information on relative hatchery/wild composition for the Klickitat was from sport catch sampling in the late 1980s, indicating that up to two-thirds of the catch were hatchery-origin. The ICTRT noted that it is possible that those estimates reflect the contribution rates in the lower Klickitat and are not directly representative of hatchery contribution rates to spawning in the majority of natural production areas. However, based on release levels and sport catch estimates, the ICTRT found that it is very likely that the hatchery contribution rate to natural steelhead spawning in the Klickitat subbasin has exceeded 5 percent for more than four generations (ICTRT 2007). Updated information from Gray (2005) indicates that 47.6 percent of the returning fish were hatchery-origin, based on the number of fish passing through the Lyle fish trap between July 2004 and February 2005. The percentage of hatchery-origin steelhead that passed through the fish trap in 2007, 2008, and 2009 ranged from 55.4 to 67.0 (http://www.ykfp.org/klickitat/).

Narum et al. (2006) argued that only 4 percent of the naturally produced steelhead could be attributed to the hatchery stock, and that genetic integrity and variation of native Klickitat River steelhead have been maintained despite repeated hatchery introductions. Berejikian and Ford (2004) estimated that the non-local Skamania Hatchery summer steelhead are less than 30 percent as effective as the naturally produced steelhead in producing returning adults.

Hatchery releases of coho and spring and fall Chinook into the mainstem Klickitat River may also affect natural steelhead production. In addition to the steelhead hatchery

releases, an average of 4,349,710 fall Chinook, 595,318 spring Chinook, and 3,714,083 coho are released into the Klickitat River each year (Sharp et al. 2008). These species are not native, but have naturalized in the basin and are known to spawn in relatively large numbers (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009).

A synthesis of many studies in other basins by Weber and Fausch (2003) indicates that competition from hatchery outplants has the potential to decrease the productivity of the rearing life stages and increase predation on wild juvenile steelhead; however, the effects of the introduction of coho and fall Chinook on steelhead production in the Klickitat River have not been evaluated. It is believed that the current release of 3.7 million coho from the hatchery downstream into the middle mainstem Klickitat River may be competing with, and preying on listed steelhead juveniles (Sharp et al. 2008). The Klickitat Master Plan (Sharp et al. 2008) proposes to reduce the annual coho releases to 1.0 million and move all releases downstream to the proposed Wahkiacus Hatchery and Acclimation Facility. Hatchery releases of juvenile fall Chinook are not expected to compete with listed steelhead because of different habitat preferences; however, they may compete with naturally produced spring Chinook (Sharp et al. 2008).

Table 5-1. Results of redd surveys completed by Yakama Nation Fisheries in the Klickitat basin, 2002 through 2007 (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009).

Year	Species	Miles Surveyed	# Redds[1]	Redds/Mile	# Live Spawners	# Morts
2002	Spring Chinook	58.1	389	6.7	248	158
	Fall Chinook	48.6	1225	25.2	1655	1133
	Coho	67.2	480	7.1	1781	384
	Steelhead	127.6	261	2.0	150	17
2003	Spring Chinook	58.1	332	5.7	213	50
	Fall Chinook	40.6	474	11.7	1423	1258
	Coho	53.8	112	2.1	424	149
	Steelhead	120.1	290	2.4	124	16
2004	Spring Chinook	70.8	195	2.8	222	57
	Fall Chinook	48.7	777	16.0	1404	776
	Coho	53.9	57	1.1	404	19
	Steelhead	142.8	220	1.5	141	6
2005	Spring Chinook	68.2	50	0.7	98	0

Year	Species	Miles Surveyed	# Redds[1]	Redds/Mile	# Live Spawners	# Morts
	Fall Chinook	48.7	505	10.4	1466	243
	Coho	40.5	0	0.0	114	21
	Steelhead	146.3	157	1.1	288	2
2006	Spring Chinook	68.2	82	1.2	68	11
	Fall Chinook	36.9	119	3.2	684	286
	Coho	40.5	1	0.0	218	45
	Steelhead	123.8	10	0.1	23	3
2007	Spring Chinook	61.2	104	1.7	70	18
	Fall Chinook	48.8	253	5.2	557	62
	Coho	56	190	3.4	1499	133
	Steelhead	135.3	67	0.5	50	8

1 The number of redds is not directly comparable between species since differences in flows affect the efficiency of the surveys.

Straying of out-of-subbasin hatchery-produced steelhead, primarily from the Snake River and Upper Columbia River, into the Klickitat subbasin may also affect the viability of the Klickitat steelhead population. These strays are believed to enter the Klickitat to flee higher temperatures in the mainstem Columbia for cooler water refuges (Keefer et al. 2002). Juvenile transportation, artificial rearing, early run timing, and multiple fallbacks/ re-ascensions at dams also seem to be related to increased incidence of straying behavior (Keefer et al. 2005). Permanent strays, as opposed to "dip-ins" in the non-natal tributary, compete with endangered native fish. Out-of-subbasin spawning by hatchery fish can directly harm local wild populations (Waples et al. 1991; Chilcote 2003). Intra-basin stray rates for hatchery steelhead into Columbia River tributaries may be as high as 6.8 percent (Keefer et al. 2005).

5.2. Freshwater Habitat

The following discussion summarizes what is known and hypothesized regarding potential limiting factors based on best available information for each major and minor spawning area (MaSA and MiSA) identified by the ICTRT. Information used to identify these factors and the potentially associated threats came from available data reports and analyses for the basin, the Northwest Power and Conservation Council's 2004 subbasin planning process, the Klickitat Lead Entity process performed under the Washington State Salmon Recovery Planning process, SB2496, a Yakama Nation 2006 EDT model run incorporating major spawning areas (unpublished), and the watershed planning process, chapter 90.82 RCW.

As described in more detail in Section 2.3, Ecosystem Conditions, and Appendix II, the Klickitat watershed offers areas of good quality habitat for steelhead as well as areas of degraded riparian condition, decreased floodplain function, altered hydrology, degraded channel structure and complexity, fish migration barriers, increased sediment loads, and degraded water quality, particularly with respect to high summer temperatures.

5.2.1 Major Spawning Areas

The ICTRT identified the following six major spawning areas in the Klickitat drainage, all of which are occupied by Middle Columbia steelhead except the West Fork Klickitat MaSA.

Upper Mainstem Major Spawning Area

As identified by the ICTRT, the Upper Mainstem MaSA contains the Klickitat River mainstem from the confluence with the West Fork Klickitat to the headwaters, including McCreedy, Chaparral, Piscoe, Diamond Fork, Butte Meadows, Coyote creeks and Huckleberry Creek below the falls. All but a small section of the Upper Mainstem Klickitat MaSA is above Castile Falls.

Potential limiting factors: *Impaired fish passage, altered sediment routing, degraded water quality (temperature), degraded channel structure and complexity, habitat quality and quantity, altered hydrology, competition, harassment/poaching.*

Steelhead recently regained access to historical habitat above Castile Falls after the fishway was modified to allow fish passage over a wider range of river flow conditions. There is historical evidence (from Yakama Nation Tribal Elders) of steelhead above Castile Falls. Historically, the difficult passage over the falls probably limited the number of fish using upstream habitat. Based on fish surveys and interviews with Tribal fishermen, LeMeir et al. (1957) identified only resident trout upstream of Castile Falls. While it is believed that the falls has always impeded upstream passage of adult fish, a 1960s attempt to improve fish passage at the falls inadvertently obstructed nearly all migration to habitat above the fishway. The recently completed fishway modifications resolved this problem. In addition to the falls, at least three culverts in Piscoe Creek have been identified as barriers to upstream juvenile and resident fish passage, according to WDFW protocols (Yakama Nation Fisheries Program 2003).

The Yakama Nation has monitored sediment levels at 20 sites in the Klickitat basin (http://www.ykfp.org/klickitat/Data_SedRpts.htm; Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009). Reported fine sediment (<0.85 mm) levels in the creek are less than 20 percent (a widely used indicator of spawning gravel condition: gravels that contain fewer than 20 percent fines are considered to be reasonably healthy for salmonids) in all mainstem sample locations in the Upper Mainstem Klickitat MaSA (Table 5-2).

Stream temperatures in the Upper Mainstem Klickitat MaSA frequently exceed 16^{o} C in summer but rarely reach lethal temperatures (Table 5-3). (http://www.ykfp.org/klickitat/Data_SedRpts.htm; Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009). Temperatures above 22^{o} C (72^{o} F) are highly stressful for steelhead but not necessarily lethal. According to Washington State Water

Quality Standards, Class A waters should not exceed 22° C, and Class AA water summer temperatures should not exceed 62.3° F.

Table 5-2. Fine sediment concentrations in gravels in the major and minor spawning areas in the Klickitat basin (data source: Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 21005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009.

MaSA/MiSA	Location	Years Sampled	Average % fine sediment (<0.85mm) in spawning gravel	Average % fine sediment (<6.73mm) in spawning gravel
West Fork Klickitat	West Fork Klickitat near the 255 road	1999	14.3	33.8
Upper Mainstem Klickitat	Klickitat near Signal Park Bridge	1999, 2001-2002	11.4	26.1
	Klickitat near Parrot's Crossing	1999-2000, 2002-2007	13.9	32.0
	Klickitat near Hatchery	1999	49.3	60.8
White Creek	Teepee Creek below IXL Road Crossing	2006	21.1	45.0
	White Creek below Teepee Creek	2005-2006	19.8	38.5
Middle Mainstem Klickitat	Klickitat below White Creek	1999-2007	12.2	31.1
	Klickitat near Leidl Bridge	1998, 2000, 2003-2007	11.1	26.1
	Klickitat near Stinson	1999-2000, 2002-2006	13.2	28.2
Lower Mainstem Klickitat	Klickitat below Little Klickitat	1999-2007	14.1	28.9
	Klickitat below Swale Creek	1999-2000, 2003-2006	13.8	35.3
Upper Little Klickitat	East Prong	1999-2000	15	30.3
	Three Creeks	1999	23.0	37.1
	Goldendale	2000	11.9	18.6

Table 5-3. Maximum recorded temperature, average annual number of days that temperature exceeds 16°C, and average annual number of days that temperature exceeds 22°C in the major and minor spawning areas in the Klickitat basin (data source: Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 21005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009.

MaSA/MiSA	Location	Years Sampled	Max Temperature	Average Annual # Days > 16°C	Average Annual # Days >22°C
West Fork Klickitat	At 255 Bridge	1997-2007	14.1	0	0
Surveyor's Creek	Surveyor's Creek Road Crossing	1996-2007	22.4	4.1	0.1
Trout Creek	At River Rte Rd	1997-2007	25.6	65.1	9.5

MaSA/MiSA	Location	Years Sampled	Max Temperature	Average Annual # Days > 16°C	Average Annual # Days >22°C
White Creek	Crossing Teepee Creek at IXL Rd Crossing	2003-2007	25.3	116	0.4
	White Creek at IXL Rd Crossing	2003-2007	23.5	21.4	1.4
Lower Little Klickitat	Near Mouth	1996-2007	27.7	81.5	11.1
	Near Confluence with Klickitat	1997-2007	25.6	65.5	9.8
Upper Little Klickitat	Three Creeks	1996-2007	26.7	59.6	10.9
Lower Klickitat Mainstem	Owen Road	1996-2005	29.8	88.4	42.8
	Near Little Klickitat	2001-2007	22.8	42.5	0.3
	At Old Lyle Trap Site	1997-2001	20.5	22.6	0.2
	At New Lyle Trap Site	2003-2004	20.9	47	0
Swale Creek	At Harms Rd	1997-2003	32.3	78.1	27.4
	Near Mouth	1997-2004	31.9	45.4	29.1

Threats in the Upper Mainstem MaSA are primarily the continued use and construction of roads, continued timber harvest in riparian areas, off-road vehicle use, and grazing. Timber harvest in this area on state and privately owned timberlands is subject to the Washington State Forest Practices rules, while harvest on the Yakama Reservation lands is governed by the Yakama Nation Forest Management Plan for 2005-2014. Future development in the upper portion of the Diamond Fork may affect habitat, depending on the use in that area, locations of development, and construction methods employed.

White Creek Major Spawning Area

The White Creek MaSA includes White Creek, Brush Creek, Tepee Creek, West Fork White Creek, and unnamed NW (White), E, NE and SE (Tepee) tributaries.

Potential limiting factors: *flow, habitat quality and quantity, impaired fish passage, altered sediment routing, degraded water quality (temperature), competition, degraded channel structure and complexity.*

The White Creek watershed (138 sq. miles), including Teepee Creek, supports a substantial portion of total observed steelhead spawning within the surveyed areas of the Klickitat subbasin (Evenson et al. 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009).

Fine sediment (<0.85 mm) levels in the White Creek exceed 20 percent in some areas (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009) (Table 5-2).

Stream temperatures in the White Creek basin frequently exceed 16°C in summer. Lethal or near-lethal temperatures occur rarely at the upper temperature monitoring sites, but exceed 22°C an average 11.1 days per year at the mouth (Table 5-3) (http://www.ykfp.org/klickitat/Data_SedRpts.htm; Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009).

Current habitat conditions in the White Creek watershed reflect past land use, particularly overgrazing, riparian timber harvest and road construction throughout the watershed. Instream large woody debris levels are low in many reaches and base flows are very low to non-existent in many reaches. Due to inhospitable flow and truncated flow duration in the vicinity of many spawning areas, post-emergence movement by steelhead fry and migration by juveniles is critical to their survival. Extensive reaches of both White and Tepee creeks have become incised and flow is now intermittent in many places where anecdotal evidence suggests it was once perennial.

Changes in channel morphology are related to livestock grazing, road interactions, and in some locations, historical removal of LWD. Impacts from grazing (in the form of altered riparian vegetation, bank erosion, and channel incision) are ongoing and evident in several meadow reaches within the watershed. At least seven culverts within the MaSA block upstream migration to spawning and rearing habitat ─ primarily for juveniles and residents, but also for some adults at some flows.

Much of Tepee Creek and portions of White and Brush creeks are highly incised with high, sparsely vegetated, eroding banks. The incision restricts floodplain access and has resulted in a higher-energy stream environment in which bed and bank erosion are common and habitat conditions are poor. Road inventory and analysis of watershed hydrology in the upper Tepee and White Creek watersheds indicated a marked increase in peak discharge (Northwest Hydraulic Consultants 2003).

LWD and pool frequency are very low (Conley 2005). Known historical failures of road crossings likely contributed to debris torrents which exacerbated downcutting of the channel bed, loss of LWD, reduced in-channel complexity and connectivity, and accelerated the export of spawning gravel. Spawning gravel and areas of velocity refugia are also limited.

Middle Mainstem Major Spawning Area

The Middle Mainstem MaSA contains the Klickitat River mainstem from the Little Klickitat River to the confluence with White Creek and includes Summit Creek, Beeks Canyon, and Dead Canyon.

Potential limiting factors: *altered sediment routing, habitat quality and quantity, degraded water quality (temperature), harassment/poaching, flow, predation, competition with hatchery fish, degraded channel structure and complexity, impaired fish passage.*

The middle mainstem Klickitat River MaSA supports over half of the observed mainstem steelhead spawning (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009), and has some of the greatest channel complexity. It also serves as the migration and rearing corridor for steelhead accessing upper reaches in the subbasin.

Large numbers of hatchery produced spring Chinook salmon, fall Chinook salmon, coho salmon and summer steelhead are released from the Klickitat Hatchery directly into the river within this MaSA (Sharp et al. 2008). These hatchery releases likely compete for food and rearing space with naturally produced steelhead. This area is also used extensively by the naturally spawning introduced fall Chinook and coho (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009), which also compete for food and rearing space.

Much of the middle mainstem Klickitat River is located in or adjacent to the Klickitat Wildlife Area. The right of way for the haul road paralleling the Klickitat River's west bank has been acquired by Columbia Land Trust. There is very little development and few roads in the unit. Some grazing occurs in the area. Logging occurs in the headwaters. As indicated in Section 2.3.2 of this Plan, the Big Muddy and Little Muddy creeks and West Fork Klickitat transport substantial quantities of sediment from a natural source to the Klickitat River above this MaSA. Logging-related impacts upstream of the MaSA might also be a source of sediment in the middle mainstem Klickitat River. However, available data suggest that fine sediment (<0.85 mm) levels in the spawning gravels in the mainstem Klickitat portion of the MaSA are reasonably low, below 20 percent fine sediment (Table 5-2) (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009). No data on stream flow, water temperatures, or levels of sediment in spawning gravels are available for Summit Creek, Beeks Canyon, or Dead Canyon.

Lower Mainstem Major Spawning Area

The Lower Mainstem MaSA extends from the mouth of the Klickitat River to the Little Klickitat River (RM 20.2) and includes Snyder Canyon, Dillacort, Wheeler and Logging Camp creeks. Lyle Falls (RM 2.19) restricts upstream passage to a degree.

Potential limiting factors: *habitat quality and quantity, competition, degraded water quality (temperature), altered sediment routing, predation, hatchery-related adverse effects, impaired fish passage, degraded channel structure and complexity, withdrawals, altered hydrology, harassment/poaching.*

The Lower Mainstem MaSA provides a migration and/or rearing corridor for 100 percent of steelhead, spring and fall Chinook, and coho in the Klickitat subbasin. The town of Klickitat is located near the upper end of the Lower Mainstem MaSA. A railroad and Highway 142 parallel the river along much of its length within the MaSA. The lower portion of the MaSA passes through a steep-sided bedrock canyon. Lyle Falls is located

near the lower end of the MaSA. The falls historically impeded passage for spring Chinook and steelhead, but prevented passage for fall Chinook and coho. Lyle Falls was first modified in 1954 to improve passage, and a major remodel of the fishway at Lyle Falls is scheduled to begin in 2010 (Sharp et al. 2008).

Data suggest that fine (<0.85 mm) sediment levels in the gravels are typically low (below 20 percent) in the mainstem Klickitat River portion of the MaSA (Table 5-2), but sediment data are not available for the tributaries within the MaSA. Data suggest that water temperatures in the mainstem Klickitat rarely reach potentially lethal temperatures (Table 5-3). Water temperatures in Snyder Creek, Logging Camp Creeks, and Dillacort Canyon frequently exceed state standards and also exceed lethal temperatures in some years (Table 5-4).

Large numbers of hatchery produced spring Chinook salmon, fall Chinook salmon, and coho salmon are released directly into the river above this MaSA, and hatchery summer steelhead are released within this MaSA (Sharp et al. 2008). These hatchery releases may compete for food and rearing space with naturally produced steelhead. Development impacts in the town of Klickitat likely have some local effect on habitat. There are stretches where the road prevents establishment of riparian vegetation. The road and railroad also impinge on the river in some locations.

Table 5-4. Summary of water temperature data collected in the tributaries included in the Lower Mainstem Major Spawning Area (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 21005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009).

Location	*Dates*	*Average Annual No. Days >16°C*	*Percent of days >18°C*	*Percent of days >22°C*
Snyder Creek at Mill	1997-2007	24.7	12.5	**0**
Snyder Creek at Mouth	1997-2007	65.5	40.6	11.2
Logging Camp Creek	2002-early 2007	59.4	43.2	10.8 (all in 2003 – 54 days total that year)
Dillacort Canyon	1997-early 2997	59.9	31.7	12.5

Upper Little Klickitat Major Spawning Area

The upper Little Klickitat MaSA encompasses the Little Klickitat River from Little Klickitat Falls to the headwaters and includes Spring, Cozy Nook, and Bloodgood creeks, West Prong and East Prong Little Klickitat, Idlewild Canyon, Dry and Butler creeks.

Potential limiting factors: *Upstream passage over a natural barrier. Other potential limiting factors include: habitat quality and quantity, flow, altered sediment routing, degraded water quality (temperature), disease, predation, competition, hatchery-related effects, and degraded channel structure and complexity.*

The upper Little Klickitat MaSA contains a mix of forested uplands managed for timber, with agricultural and grazing land in the lower region. As of the 2000 census, the City of

Goldendale, which has a population of approximately 3760 people (www.census.gov), is the only urban development in the Little Klickitat watershed. The two main thoroughfares of the Klickitat subbasin, SR 142 and US 97, converge at and pass through Goldendale. Hatchery rainbow trout are released into this MaSA to support recreational fisheries.

Little Klickitat Falls, located at river mile 6.1, is 15 to 16 feet high (WPN and Aspect 2005a). Fish passage is possible in rare cases, but these tend to be very high flow events (floods) in winter (D. Rawding, personal communication 2006). In some years when a very high flow event coincides with the time steelhead are moving upstream, a few fish may pass the falls and enter the MaSA. The presence of the barrier functionally excludes steelhead from the upper Little Klickitat MaSA in most years.

Water temperature in the Little Klickitat River frequently exceeds the state standard and can exceed the likely lethal temperature in some areas (Table 3, Broack and Stohr 2002). The East Prong, West Prong, and mainstem Little Klickitat River; and Butler Creek, a major tributary to the Little Klickitat River, were listed on the 1998 303(d) list for temperature. Subsequently, a TMDL assessment and implementation plan were developed and adopted for the Little Klickitat River subbasin (Brock and Stohr 2002; Anderson 2004). Currently, the Little Klickitat River is listed as a Category 4b stream, meaning that the stream has an approved TMDL in place that is actively being implemented (Ecology 2008).

Since steelhead rarely pass the falls, water temperatures in the Upper Little Klickitat MaSA likely do not affect overall steelhead production, except for the influence on water temperature downstream of the falls. A recent analysis of the trends in riparian vegetation within the Little Klickitat basin indicated that riparian vegetation has generally been increasing over the past 30 to 40 years (Aspect and WPN 2009).

Sediment inputs into the Little Klickitat River MaSA could potentially affect spawning areas in the lower Little Klickitat MiSA. A Watershed Analysis was completed for the headwaters of the Little Klickitat basin in 1999 (Raines et al. 1999). That analysis indicated that forest roads were contributing significant sediment to the headwater streams. Since the analysis was completed, the new Washington Forest Practices Rules were adopted; this area is now covered under a Habitat Conservation Plan (http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesHCP/Pages/fp_hcp.aspx). The rules mandate the treatment of roads to minimize sediment inputs.

West Fork Klickitat Major Spawning Area

The West Fork MaSA includes the West Fork Klickitat River from top of falls #1 to headwaters, including Clearwater, Trappers and Fish Lake creeks.

Potential limiting factors: Natural passage barriers and possibly altered sediment routing.

A falls that totals 15 feet at RM 0.3 on the West Fork Klickitat currently hinders upstream anadromous fish passage, and probably limited historical passage to upstream habitat (LeMeir and Smith 1952). Another falls, 15 to 20 feet high, lies approximately four miles upstream and likely poses a similar challenge to upstream migration. LeMeir and Smith (1952) considered these falls to be passage barriers. Although some potential spawning areas exist in the watershed, factors such as gradient and natural confinement contribute to the assumption that this watershed would not be heavily used by spawning anadromous fish (though it is a stronghold for bull trout).

This watershed ranked low in EDT model outputs for restoration potential, since existing data suggest that the West Fork environment has not been significantly altered from historical conditions. Currently, the biggest threat in the watershed is road failures upstream of fish-bearing reaches, which generate torrents and contribute fine sediment. Determining the extent and frequency of steelhead passage and spawning in this system is considered a research need.

5.2.2 Minor Spawning Areas

Swale Creek Minor Spawning Area

The Swale Creek MiSA includes Swale Creek from the mouth to the south tributary below Harms Rd (RM 12.22).

Potential limiting factors: *It is likely that high stream temperature and low stream flow are limiting factors in this MiSA. Degraded habitat quality and quantity, altered sediment routing, disease, competition, predation, and degraded channel structure and complexity are also potential limiting factors.*

Stream flow in Swale Creek is intermittent near the mouth and upstream of river mile 3.1 (WPN and Aspect, 2005a). Stream flow in the lower 3 miles of the creek has been estimated at less than 0.25 cfs during summer (WPN and Aspect 2005a, Aspect 2007).

Stream flow in Swale Creek is influenced by a unique geological situation. The Warwick Fault, running northwest-southeast through Warwick (at roughly RM 12), is an important structural control on groundwater flow in the basin (WPN and Aspect, 2005a; Aspect 2007). The fault forms a structural closure to the Swale Creek valley and creates an impoundment of groundwater to the east of the fault. The presence of the fault impedes westerly groundwater flow (WPN and Aspect 2005a; Aspect 2007). The upper and lower portions of Swale Creek are hydrologically connected in winter and spring when the alluvium upstream of the fault is saturated, resulting in surface flow. The groundwater subsequently drops after the spring rains. The upper and lower basins become hydrologically isolated once the groundwater level drops below the top of the fault. This normally occurs in April or May. Water present in Swale Creek in summer and fall downstream of Warwick is an expression of local seeps and springs located below the fault (WPN and Aspect, 2005a; Aspect 2007).

The cadastral survey notes of the 1800s generally indicate that the flow situation in the 1860s was similar to what is seen today (WPN and Aspect, 2005a). Studies of the local

geology and groundwater flow in the area also indicate that it is unlikely that land use has affected the quantity of water entering this segment (WPN and Aspect, 2005a).

Swale Creek has been listed as Category 5 (impaired, requires a water quality improvement plan) on the State of Washington's 303(d) list for exceedances of state temperature criteria (Ecology 2008). Water temperature at all monitoring stations exceed 22°C (potentially lethal) in all years (WPN and Aspect, 2005a). Since the creek is isolated from the Klickitat River in summer and movement of juvenile fish into the Klickitat is prevented, juveniles rearing in Swale Creek are likely subject to significant mortality when water temperatures rise above potentially lethal temperatures.

Riparian vegetation along the lower 3 miles of the creek, which are perennially wet, is generally dense (WPN and Aspect, 2005a). A review of aerial photographs taken since 1954 indicated that vegetation over the last 60 years has been influenced by a number of large flooding events that removed mature vegetation (WPN and Aspect, 2005a). An analysis of the trends in vegetation over time found that vegetation has generally been increasing along Swale Creek over the past 30 to 40 years (Aspect and WPN 2009).

Limited information is available regarding other habitat conditions in the MiSA. An abandoned railroad bed confines the creek upstream of the perennial wetted area.

Surveyor's Creek Minor Spawning Area

The Surveyor's Creek MiSA contains branched habitat from Surveyor's Creek. The MiSA, as shown in Figure 4-4, contains mainstem Klickitat habitat, but this is only due to the methodology of using existing Hydrologic Unit Code (HUC) GIS data where possible. In this case, because the relevant HUC for Surveyor's Creek was selected, the MiSA encompassed other reaches that did not meet branched habitat criteria but were within the HUC boundary.

Potential limiting factors: *Upstream passage is the primary limiting factor. Other potential limiting factors are altered sediment routing, water temperature, and competition.*

The stream is impassable to salmon and steelhead. Between the mouth of the creek and a location approximately 0.8 miles upstream, the creek drops about 400 feet in a series of cascades and impassable falls (LeMeir 1952). Water temperatures frequently exceed 16°C, and occasionally reach potentially lethal temperatures (Table 5-3).

Lower Little Klickitat Minor Spawning Area

The Lower Little Klickitat MiSA covers the Little Klickitat River from the mouth to Little Klickitat Falls (RM 6.2), including lower Canyon and Bowman creeks.

Potential limiting factors: *Temperature is likely the primary limiting factor in the Lower Little Klickitat MiSA. The following are also potential limiting factors: disease,*

altered sediment routing, competition, habitat quality and quantity, predation, flow, and hatchery-related effects.

The lower 6.1 miles of the Little Klickitat River provide rearing and limited spawning habitat for steelhead. Much of the MiSA runs through a deep canyon. There is little development along the canyon reach. Lower in the reach, some grazing and minor jeep trails are present. The mainstem Little Klickitat River and its tributaries Mill Creek and Bowman Creek are listed as a Category 4a for temperature on Ecology's 303(d) list (Ecology 2008). Water temperatures regularly exceed the state standard in summer and occasionally exceed potentially lethal temperatures (Table 5-3). Riparian vegetation has generally increased since 1969 within the MiSA (Aspect and WPN 2009). The Little Klickitat TMDL (Anderson 2004, Brock and Stohr 2002) includes the Lower Little Klickitat River MiSA. The WRIA 30 Management Plan (WPN and Aspect 2005b) and the TMDL outline actions that should be taken to address temperature in the MiSA. Little to no data are available to address any other factors in this MiSA.

Trout Creek Minor Spawning Area

The Trout Creek MiSA extends up Trout Creek from the top of the falls to the headwaters and includes Bear Creek.

Potential limiting factors: *Natural passage barrier. The following are also potential limiting factors: altered sediment routing, competition, degraded water quality (temperature), habitat quality and quantity, and flow.*

Lower Trout Creek has a relatively steep gradient (20-25 percent over almost 0.25 miles). It is composed primarily of a boulder substrate, which does not, however, exceed the WDFW criteria for anadromous fish-bearing waters (20 percent gradient for 160 meters - continuous, or waterfall over 12 feet in height). No steelhead have been observed to date above the high gradient reach (Evenson and Zendt 2004; Yakama Nation Fisheries Program 2003; Zendt and Evenson 2005; Zendt and Babcock 2007; Zendt 2006; Zendt and Babcock 2009).

5.3 Tributary Harvest

In the Klickitat River, there is both a recreational harvest and a Native American treaty harvest. Recreational fisheries for winter and summer steelhead occur in the Klickitat River from June 1 through November 30. Most steelhead are caught from June through September. A dip net fishery exclusive to enrolled Yakama tribal members is located at Lyle Falls (RM 2). Fishing seasons are set annually by the Yakama tribal council and are subject to in-year closures depending on run strength. The tribal steelhead dip net fishery generally occurs from April 1 through December 31. Harvest is monitored by Yakama Nation fisheries program personnel.

Recreational steelhead fisheries in the Klickitat River are restricted to adipose fin-clipped hatchery steelhead only. Current regulations prohibit sport fishing for steelhead in the Klickitat River from December through May, and the treaty fishery is closed from January through March to protect the winter run (Bosch et al. 2004). Release of all

unmarked wild steelhead is required. Tribal harvest regulations do not require the release of unmarked fish; however, many tribal fishers are returning wild fish to the river (J. Kiona, personal communication 2005). The Klickitat River Anadromous Fisheries Master Plan proposes to use an education outreach program to encourage more tribal fishers to adopt this practice while still respecting tribal culture and tradition (Sharp et al. 2008).

The overall mortality rate for catch-and-release fisheries depends on the encounter rate of naturally produced fish (percentage of run actually caught and released) in the fisheries, and the mortality rate associated with being caught and released (hook-and-release mortality). In winter steelhead fisheries, WDFW (2008) estimates that catch-and-release mortality is less than 5 percent, while mortality in summer steelhead fisheries in the Klickitat River is estimated to be less than 10 percent of the wild fish handled. The catch and release mortality only affects that proportion of the wild run that is encountered in the fishery. WDFW (2008) estimates that in the Klickitat River tributary fisheries that 63 percent of the summer-run steelhead and 34 percent of the winter-run steelhead are handled. Multiplying the catch and release mortality rates by the encounter rates provides the estimate of tributary fisheries impacts of 6 percent for summer-run and 2 percent for winter-run wild steelhead (WDFW 2008).

ODFW performed a number of Population Viability Assessment model runs for 27 steelhead populations to assess the impact of fisheries mortality on the status and recovery of steelhead in Oregon (Chilcote 2001). As mortality rates became greater than 40 percent the probability of extinction increased dramatically. To address this concern, steelhead fisheries are managed not to exceed a maximum mortality limit of 20 percent. This conservative approach is used to provide a buffer for errors, even though the model results suggest that management under a 40 percent limit is unlikely to cause extinction.

Treaty Native American fisheries also occur in the mainstem Klickitat River. The treaty Native American catch of all types of steelhead (summer and winter, wild and hatchery combined) in the Klickitat River is estimated at an average of 1,146 steelhead per year since 1986 (Sharp et al. 2008). Estimated tribal harvest of wild steelhead in the Klickitat averages 178 fish per year (Table 2-1) (Sharp et al. 2008).

Steelhead harvest (sport and tribal combined) in the Klickitat River has averaged about 2,500 fish annually from 1987 to 2004, with Skamania strain steelhead comprising an average 98.1 percent of the sport catch from 1986-2003 (Table 5-5). By contrast, a sport harvest-only table covering the years 1962-1966 averaged an annual catch of 3,312 steelhead (summer only), peaking in 1966 at 8,093 fish (Washington Department of Game and Oregon State Game Commission 1968).

Table 5-5. Estimated Harvest for Klickitat River Steelhead, 1986-2007 (Sharp et al. 2008).

Year	Sport			Tribal		
	Hatchery	Wild	Total	Hatchery[1]	Wild[1]	Total
1986-87	1,426	54	1,480	5,107	901	6,008
1987-88	1,480	34	1,514	1,141	201	1,342
1988-89	1,718	0	1,718	1,263	223	1,486
1989-90	833	0	833	536	95	631
1990-91	1,055	0	1,055	1,464	258	1,722
1991-92	823	8	831	1,620	286	1,906
1992-93	1,260	0	1,260	1,033	182	1,215
1993-94	1,211	25	1,236	1,151	203	1,354
1994-95	857	34	891	482	85	567
1995-96	864	9	873	433	76	509
1996-97	608	14	622	241	43	284
1997-98	1,062	18	1,080	455	80	535
1998-99	650	12	662	224	39	263
1999-00	575	28	603	214	0	214
2000-01	1,433	59	1,492	495	67	562
2001-02	3,708	16	3,724	724	55	779
2002-03	3,552	97	3,649	1285	363	1,648
2003-04[2]	1,673	0	1,673	369	151	520
2004-05	1,658	0	1,658	747	153	900
2005-06	1,115	0	1,115	368	98	466
2006-07					61	
Avg:	1,378	20	1,398	968	178	1,146

Note: Data for this table are from YN and WDFW databases and US v. Oregon TAC reports

[1]Hatchery and wild proportions of tribal harvest are estimated as follows: For 1999-00 through 2005-06 percentages estimated from sampling of ceremonial and subsistence harvest were applied to total tribal harvest.
For 1986-87 through 1998-99 the average percentages from the 1999-2005 sampling were applied to total tribal harvest.
[2]Sport Harvest numbers include data from May 1 - April 30 except for 2003-04, which does not include April data

In the most recent ten years between 1997-98 and 2006-07, tribal harvest of wild steelhead in the Klickitat has ranged from 0 to 363 with an average of 107 fish annually (Table 5-5 above). Estimated harvest rates derived for years prior to 2005-06 are likely biased in favor of high returns, as a result of underestimated spawner escapement and total run size to the mouth of the Klickitat. For the return years of 2005-06 and 2006-07, estimated tribal harvest rates on wild steelhead were 5.8 percent and 3.5 percent, respectively (based on wild run abundance and tribal harvest below Lyle Falls as described in Appendix IV). Expansion of the spawner escapement estimates for harvest prior to these two years would suggest a much higher rate upward around 15 percent for the period of record of 1986-2007. Considering the recent two year average of 4.7 percent expanded from the mark recapture abundance estimates, actual harvest over the

recent ten year period of record has probably ranged from 3.5 percent - 10 percent of the wild run to the mouth of the Klickitat.

Steelhead occupy many waters that are also occupied by resident trout species. It is not possible to visually separate juvenile steelhead from similarly sized stream-resident rainbow trout. Because juvenile steelhead and resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout also apply to juvenile steelhead. WDFW has implemented a number of regulation changes to limit impacts on juvenile steelhead in the Klickitat River. These include increasing the minimum size limit for rainbow trout fisheries from 6 inches to the current size limit of 12 inches. The daily bag limit was also reduced from 6 fish to 2 fish. Trout angling is only open from June 1 to November 30. These changes have reduced impacts on naturally produced juvenile steelhead/trout to less than 1 percent of the population, a substantial reduction from historical impacts of tributary fisheries, which were estimated to be over 50 percent (WDFW 2008). The continued release of rainbow trout in tributaries to the Little Klickitat River and the associated fisheries that do not follow the same regulations may adversely affect those naturally produced steelhead that are able to pass above the falls in the lower Little Klickitat River. Fisheries that target non-resident warm water species can affect juvenile steelhead but these fisheries are not present in the Klickitat River (WDFW 2008). WDFW has submitted to NMFS a Fisheries Management and Evaluation Plan (FMEP) for tributary fisheries in the Middle Columbia steelhead DPS to cover impacts from these fisheries under the 4(d) rule limit 4 of the ESA (WDFW 2008).

Harvest of salmon and steelhead in the Klickitat River may include “dip-in” fish, which are destined for tributaries farther up the Columbia and Snake river systems, but temporarily stray to the Klickitat’s cool water refuges in the river’s lower reaches for short periods before continuing their upstream migrations. The contribution of dip-in hatchery steelhead in the Klickitat River harvest is believed to be small. Most hatchery steelhead are taken from river sections upstream of where dip-in fish are found, and the proportion of the harvest is primarily 2- and 3-salt fish typical of the Klickitat River steelhead (D. Rawding, personal communication 2006).

5.4 Out-of-Subbasin Limiting Factors and Threats

The Middle Columbia River Steelhead DPS Recovery Plan uses information from two “modules” developed by NMFS to address conditions in the Columbia River mainstem and estuary that affect all Middle Columbia steelhead: the Hydro Module, based on the NMFS 2008 Biological Opinion on the Federal Columbia River Power System, and the Estuary Module (NMFS 2007). In addition to proposed actions in the management unit plans, the DPS Plan relies upon Hatchery and Genetic Management Plans and Artificial Production for Pacific Salmon (Appendix C of the Supplemental Comprehensive Analysis, NMFS 2008 Biological Opinion) to address hatchery effects. For harvest effects, the Plan refers to fishery management planning through the 2008 U.S. v. Oregon agreement for mainstem fisheries, and Fisheries Management Evaluation Plans for

tributary fisheries. The reader is referred to the DPS plan for this information. The following is a summary of the information most relevant to the Klickitat Plan.

5.4.1 Harvest

Steelhead destined for the Klickitat drainage can be caught in three types of fisheries as they migrate through the Columbia River and Pacific Ocean: ocean fisheries or mainstem Columbia River tribal or nontribal fisheries.

Ocean Fisheries

Steelhead are rarely caught in ocean fisheries; therefore, these fisheries are not considered a significant source of mortality to Middle Columbia River steelhead (NMFS 2000). Ocean fishing mortality on Middle Columbia River steelhead is assumed to be zero.

Columbia River Mainstem Non-Tribal Fisheries

There has been no direct freshwater non-tribal harvest on wild steelhead from the Mid-Columbia DPS since 1992, when the last wild fish catch-and-release regulations on these populations became effective. Therefore, all current non-tribal harvest impacts on Mid-Columbia DPS steelhead are due to incidental bycatch in commercial or recreational fisheries that target hatchery steelhead or other species, and monitoring these impacts is complex. Released fish experience a mortality rate, possibly delayed and difficult to measure, that is highly variable and depends on what gear is used, how the fish is caught by the gear, how the fish are handled during capture and release, and environmental conditions. Release mortality is estimated to be very low (below 1 percent of encounters), with an unknown range of error. Recreational fisheries are monitored by creel surveys (fisheries technicians interview anglers about their catch, gear, and wild steelhead releases); the total recreational impact on winter and summer steelhead as they move through the mainstem to the tributaries is estimated to be less than 2.5 percent (ODFW 2009, Oregon Recovery Plan).

There are three stocks of summer steelhead used for management of treaty and non-treaty mainstem fisheries, including the lower Columbia River Skamania stock, upriver A-run stock, and upriver B-run stock. All MCR steelhead populations are designated A-run, with two populations being winter run. In NOAA's Biological Opinion for the 2008-2017 *U.S. v. Oregon* Fisheries Agreement the wild MCR steelhead DPS in the non-treaty winter, spring, and summer mainstem fisheries are subject to a 2 percent harvest rate limit (NMFS 2008b). Non-treaty fall fisheries are also limited to a 2 percent harvest rate limit for A-run summer steelhead. The total annual harvest rate limit for A-run steelhead in non-treaty fisheries is 4 percent and 2 percent for the summer-run and winter-run of the MCR steelhead DPS, respectively. The expected harvest impacts from non-treaty fisheries are less than the limits proposed in the *U.S. v. Oregon* fisheries Agreement. The yearly incidental catch of A-run steelhead in non-treaty fisheries has averaged 1.6 percent since 1999, and is not expected to change over the course of the Agreement (NMFS 2008b).

Treaty Native American Fisheries

Tribal fishers in Zone 6 of the Columbia mainstem (between Bonneville Dam and McNary Dam) continue to retain wild steelhead for commercial sale or for personal use. The *U.S. v. Oregon* Fisheries Agreement does not establish specific harvest rate limits for treaty-Native American fisheries on steelhead during the spring or summer seasons which extend through July 31. Reported steelhead catch in Zone 6 winter and spring fisheries for 2003 to 2005 ranged from 0.7 percent to 7.9 percent of the winter steelhead run over Bonneville Dam. In 2004, reported and estimated non-reported steelhead catch together amounted to 4.8 percent of the run at Bonneville, with an unknown error around these numbers (ODFW 2009, Oregon Recovery Plan).

Impacts on MCR steelhead from treaty-Native American fall fisheries are limited by harvest rate limits for B-run steelhead and Upper Columbia River bright fall Chinook (NMFS 2008b). The harvest rate on MCR summer-run steelhead in spring, summer, and fall Zone 6 treaty-Native American fisheries combined averaged 11.7 percent since 1985 and 6.64 percent since 1998 (NMFS 2008b, Table 8.8.5.5-1). The impacts resulting from the treaty- Native American fisheries are expected to be similar to the 1998-2006 average of 6.64 percent. The harvest rate is less for populations that pass fewer dams in Zone 6 and are therefore subject to fewer non- Native American and treaty Native American fisheries (e.g., Klickitat steelhead pass only one dam and would experience a harvest rate less than 6.64 percent).

5.4.2 Columbia River Hydro Operations

Hydropower system construction and operation (flow regulation) in the Columbia River basin has been a major cause of changes in the Columbia River and estuary from historical conditions.

Within the Klickitat subbasin, steelhead and salmon were affected by creation of the Bonneville Dam pool on the mainstem Columbia River, which effectively inundated the lower 1.19 miles of the Klickitat River. This resulted in the loss of riparian, spawning, and rearing habitat and increased predation by native and non-native fish in the lower river. A lack of historical data inhibits quantitative evaluation of the impacts of Bonneville pool inundation on native fish, plant and wildlife species.

In the mainstem Columbia River, changes in river flow, circulation, water quality, contaminants, channel alterations, and predation have negative impacts on adult and juvenile fish. Hydro operations have changed flow conditions in the Columbia River and through the estuary. Before the development of the hydrosystem, Columbia River flows were characterized by high spring runoff from snowmelt and regular winter and spring floods. Dam construction and operation have altered Columbia River flow patterns substantially throughout its basin. Historical flow records at The Dalles, Bonneville Dam, and Beaver, Oregon, demonstrate that annual peak flows have been reduced by about 50 percent, as water is stored for power generation and irrigation, and winter flows have increased about 30 percent.

The Columbia River Estuary Module, at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery -Plans/upload/Estuary-Module.pdf provides more information on factors that limit viability of Klickitat steelhead in the Columbia River Estuary.

5.4.3 Ocean Conditions

The effects of ocean conditions on abundance of Pacific salmon and steelhead vary among species and populations within species. Migration patterns in the ocean may differ dramatically and expose different stocks to different conditions in different parts of the ocean. Some species have broad, offshore migration patterns that may extend as far as the Gulf of Alaska (steelhead, chum, some Chinook). Others have migration patterns along the Washington, British Columbia, Oregon and California coasts (Chinook, coho, cutthroat). Thus, ocean conditions do not have coincident effects on survival across species or populations.

Ocean survival of steelhead has been dramatically affected by widespread changes in ocean conditions. Cooper and Johnson (1992) showed that variation in steelhead run sizes and smolt-to-adult survival was highly correlated between runs up and down the West Coast. Smolt-to-adult survival rates generally varied 10-fold between good and bad years. Ocean survival rates for three West Coast steelhead populations where good annual index data were available showed high variability and a generally declining trend since the late 1970s.

5.4.4 Climate Change

Climate change represents a potentially significant threat to recovery of Mid-Columbia steelhead populations. The Independent Scientific Advisory Board (ISAB) for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and NMFS reviewed the potential effects of climate change on salmonids in the Columbia River basin (ISAB 2007). The ISAB report shows that changes in climate may adversely affect steelhead in freshwater habitats across the DPS by exacerbating existing problems with water quantity (lower summer stream flows) and water quality (higher summer water temperatures). Consistently identified types of impacts on snow pack, stream flow, and water quality in the Columbia Basin are the following (ISAB 2007 p. 15-17):

- Warmer temperatures will result in more precipitation falling as rain rather than snow.
- Snow pack will diminish, and the timing of stream flow will be altered.
- Peak river flows will likely increase.
- Water temperatures will continue to rise.

These changes may affect steelhead more than other salmonids because of their long rearing period in freshwater.

Changing conditions could also affect salmonid health and survival in the ocean through a variety of mechanisms, including increased ocean temperatures, increased stratification of some waters, changes in the upwelling season, shifts in the distribution of salmonids,

long-term variability in winds and ocean temperatures, increased acidity, and increased atmospheric and oceanic variability (NMFS 2007, 2008a; ISAB 2007).

All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat can be expected to cause a reduction in the number of naturally produced adult steelhead returning to these populations across the DPS. This possibility further reinforces the importance of achieving survival improvements throughout the entire steelhead life cycle. Recent research also indicates that neighboring populations with differences in habitat may show different responses to climate changes (Crozier and Zabel 2006; Crozier et al. 2008). This research reinforces the importance of maintaining habitat diversity. Ongoing efforts to develop models of future climate effects should be considered in adaptive management.

5.4.5 Other Large-Scale Threats

Projected continued population growth will increase pressures for conversion of forestry and agricultural land uses to residential uses, with potential impacts on habitat and water conditions.

- Increase in exotic invasive species that potentially compete with native flora and fauna, and provide food and/or cover to species that potentially compete with, prey on or carry diseases which could affect native species.
- New disease and/or pathogen introductions (e.g. from marine aquaculture operations on steelhead ocean migration routes, illegal stocking of out-of-subbasin species).
- Natural catastrophic events (e.g. earthquake, volcanic eruption and related effects).

6. Recovery Strategy and Actions

The preceding chapters summarize recovery goals, biological criteria and threats criteria, current status assessment, and the major limiting factors and threats identified for the Klickitat River steelhead population. How will we reach recovery?

In this chapter, a recovery strategy is laid out to address the significant data gaps and uncertainties regarding the status of the Klickitat steelhead population and to address the potential limiting factors based on the existing, best available science; i.e. hatchery-related effects and degraded habitat, including natural barriers to fish passage. The strategy includes maintaining low harvest impacts and improving monitoring to verify those impacts. Fish passage and survival issues in the mainstem Columbia River and estuary are addressed in more detail in the Middle Columbia River Steelhead DPS ESA Recovery Plan; in Section 6.5, these are summarized as most directly related to the Klickitat population.

Lack of information about the Klickitat River steelhead population is a major problem for recovery planning for the Middle Columbia River steelhead DPS. The Klickitat population's moderate risk rating was assigned primarily on the basis of uncertainty and lack of data, particularly with respect to the influence of hatchery fish on the wild steelhead population. Therefore, the first importance for a recovery strategy is to reduce the uncertainties by obtaining more information through monitoring and research. Monitoring and research needs are summarized here and described in greater detail in Chapter 8.

Improvements in hatchery management and the construction of a new facility 26 river miles downstream of the major spawning area in the middle mainstem are designed to address the potential limiting factor of competition with hatchery fish.

To address habitat degradation in the Klickitat watershed, the plan proposes to protect and improve ecosystem functions and restore ecological processes, first, by protecting and maintaining existing high quality and/or unimpaired habitats and ecosystem functions; and, second, by restoring degraded habitat where appropriate, through passive and active measures.

Managing harvest for low impacts from both mainstem and tributary fisheries, and to reduce any adverse impacts that may be occurring, also is an important contribution to the population's viability.

For a species to achieve both ESA and broad-sense recovery, it would need to get on a definitive trajectory of improvement. The recovery strategies and actions are designed to work synergistically to improve survival throughout the steelhead life cycle, from egg to smolt to returning adult. Monitoring results will inform us of the progress the species has made toward recovery goals.

6.1 Strategies and Actions to Address Data Gaps

A research, monitoring, and evaluation plan should be designed collaboratively in the implementation phase of this plan to address the additional information needs that stakeholders and scientists have identified, as follows:

- Determine abundance and productivity of natural steelhead spawners
- Determine the impacts of Skamania hatchery steelhead releases on viability of the Klickitat population, if any.
- Determine the effects of non-native coho and fall Chinook released from the hatcheries and naturalized in the river, if any.
- Continue study and further refine understanding of habitat limiting factors.

Strategy 1. Determine abundance and productivity of natural steelhead spawners

Actions

- *Fin clipping of hatchery fish* – Continue fin clipping 100 percent of the hatchery released fish to facilitate the development of population estimates.

- *Adult counts at Lyle Falls Fishway adult trap* – Continue to monitor the number of steelhead passing through the Lyle Falls adult trap.

- *Estimates of trap efficiency* – Continue to monitor adult trap efficiencies with floy tags recovered in sport fisheries or during spawner/carcass surveys. Testing trap efficiency may be improved by releasing floy tagged fish downstream of the trap and identifying the percentage that re-enter the trap as they move upstream. Develop and publish annual estimates of trap efficiency.

- *Abundance estimates* – Based on the number of fish caught in the Lyle Falls Fishway adult trap and the estimates of trap efficiency, develop and publish annual estimates of the number of natural spawners.

- *Juvenile counts at the smolt trap locations* – Continue to monitor and report the number of fish caught in the three rotary screw trap locations currently operated by Yakama Nation Fisheries in cooperation with WDFW.

- *Productivity estimates* – Based on the number of fish caught at the rotary screw trap locations and the estimates of trap efficiency, develop and publish annual estimates of the number of naturally spawned steelhead smolts migrating out of the Klickitat basin.

Strategy 2. Determine impacts of Skamania Hatchery steelhead releases on viability of Klickitat steelhead population.

Actions

- *Spawner Surveys* -Continue to conduct and report annual spawner surveys to track adult steelhead distribution in the MaSAs and MiSAs.

- *Portion of Natural Spawners of Hatchery-Origin* - Estimate natural/hatchery adult spawner ratios by sampling carcasses on spawning grounds, or through other appropriate methods.

- *Estimates of Genetic Introgression* - Based on the estimated proportion of hatchery-origin steelhead spawning naturally each year, develop estimates of the amount of genetic introgression that has likely occurred over the 40 years of hatchery operations.

- *Genetic Sampling* - Increase juvenile and adult genetic sampling and analysis at spawning grounds and at various trap locations to help assess the level of domestication and interbreeding between hatchery and natural steelhead.

- *Stock Distribution* - Focus radio-tagging studies to determine spatial and temporal distribution of natural Klickitat steelhead population and Skamania Hatchery steelhead, and the overlap between summer and winter-run steelhead in the Klickitat River.

Strategy 3. Determine impacts of non-native coho and fall Chinook releases on viability of Klickitat steelhead population.

Actions

- *Fin clipping of hatchery fish* **–** Continue fin clipping 100 percent of the hatchery released coho and fall Chinook to identify the number of hatchery released fish that spawn naturally in the Klickitat River.

- *Adult counts at Lyle Falls Fishway adult trap* – Continue to monitor the number of coho and Chinook passing through the Lyle Falls adult trap.

- *Estimates of trap efficiency* **–** Estimate the efficiency of the trap in intercepting coho, fall Chinook, and spring Chinook. Publish annual estimates.

- *Abundance estimates* – Based on the number of fish caught in the Lyle Falls Fishway adult trap and the estimates of trap efficiency, make annual estimates of the number of adult coho, fall Chinook, and spring Chinook entering the Klickitat basin.

- *Juvenile counts at the smolt trap locations* – Continue to monitor and report the number of coho and Chinook caught in the three rotary screw trap locations currently operated by the Yakama Nation Fisheries in cooperation with WDFW.

- *Productivity estimates* - Based on the number of coho and Chinook caught at the rotary screw trap locations and the estimates of trap efficiency, develop and publish annual estimates of the number of coho and Chinook smolts migrating out of the Klickitat basin.

- *Spawner surveys* - Continue to conduct annual spawner surveys to track adult coho and fall Chinook distribution in the MaSAs and MiSAs, but expand the program to cover the entire area in which steelhead are known to spawn.

- *Estimate number of naturally spawning fish of hatchery-origin* - Sample carcasses on spawning grounds to estimate natural/hatchery adult spawner ratios.

- *Overlap in distribution of spawning habitats* - Assess the amount of overlap in the habitat occupied by steelhead and the introduced species.

- *Productivity of introduced species* - Determine the productivity of the naturally spawned coho and fall Chinook, using the same methods used to determine the productivity of steelhead.

- *Competition between species* – Evaluate the effects of competition with introduced species on rearing juveniles (differences in growth and survival with and without introduced species present) in a properly controlled experiment.

- *Estimate displacement of steelhead* - Determine the area of steelhead spawning and rearing habitat displaced by coho and fall Chinook.

- *Effects of introduced species on productivity* - Estimate the effect of introduced species on the productivity of steelhead in the basin.

Strategy 4. Continue study and further refine understanding of habitat limiting factors.

Actions

- Continue habitat study and incorporate new data into EDT, AHA, and/or other appropriate models.

- Continue biological studies and incorporate new data into models.

- Use adaptive management to adjust actions according to new information.

6.2 Hatchery-Related Strategies and Actions

The following strategies and actions address potential limiting factors and threats to Klickitat steelhead viability from hatchery-related effects.

Strategy 1. Minimize adverse impacts of large-scale hatchery releases of *U.S. v. Oregon* production stocks (coho and fall Chinook) on Klickitat steelhead population.

A satellite Wahkiacus Hatchery/Acclimation Facility (WHAF) at RM 17.0 on the Klickitat River is under development. Existing *U.S. v. Oregon* production of fall Chinook and coho will be transferred from the Klickitat Hatchery to the new facility. The 26 miles of river between Klickitat Hatchery (RM 42.6) and WHAF (RM 17) contain EDT reaches in the upper end of the Lower Klickitat, Middle Klickitat, and Upper Middle Klickitat MaSAs (See Appendix II, Table II-1 for correlation between ICTRT and YN MaSAs and MiSAs). Physical habitat surveys and resulting EDT output identify these reaches as having the highest potential for restoration and preservation. Annual steelhead spawner surveys indicate that 60 percent of the mainstem spawning occurs in these reaches.

The program is identified in the Klickitat Anadromous Fishery Master Plan (Sharp et al. 2008). Transferring *U.S. v. Oregon* production stocks (coho and fall Chinook) to the WHAF accomplishes two primary objectives. First, it frees up critical water and space at the Klickitat Hatchery, ensuring that optimal rearing densities and protocols (YKFP and HSRG guidelines) are met for the two endemic stocks (Klickitat spring Chinook and Klickitat summer steelhead). Second, transferring coho and fall Chinook production 26 miles downriver minimizes the impacts of large-scale hatchery releases on wild spring Chinook and steelhead rearing between the two facilities. Additionally, release of well-acclimated coho and fall Chinook from WHAF imprinted to the local groundwater signature will concentrate natural production in the immediate vicinity of the facility.

Actions

- Develop satellite Wahkiacus Hatchery/Acclimation Facility at RM 17.0.
- Transfer existing *U.S. v. Oregon* production of fall Chinook and coho from the Klickitat Hatchery to Wahkiacus facility.

Strategy 2. Minimize adverse impacts from hatchery program on the Klickitat steelhead population.

The Yakama Nation has been working with, the HSRG, NMFS, WDFW, Tribal fish and wildlife leaders, BPA, and others to develop a master plan for an integrated hatchery program for the Klickitat River (Sharp et al. 2008). The program will minimize adverse impacts on the natural steelhead spawning population. One option being explored by hatchery program managers is to replace the current program, which releases out-of-basin Skamania hatchery-origin smolts in the Klickitat River system, with a hatchery program that relies entirely on the use of natural-origin, summer steelhead from the Klickitat River for broodstock (Sharp et al. 2008). The new program would continue to provide harvest opportunities for treaty and non-treaty fisheries. A feasibility study will be conducted as

part of the program to investigate broodstock collection and juvenile rearing strategies, expected smolt-to-adult survival rates, and the risks associated with current steelhead hatchery practices.

Actions

- Develop and implement Klickitat steelhead integrated hatchery program (Sharp et al. 2008).
- Conduct feasibility study to gain needed information on broodstock collection, rearing strategies and expected smolt-to-adult survival rates, and to assess risks associated with current and proposed hatchery practices.
- Evaluate out-of-basin steelhead strays.

Strategy 3. Improve steelhead passage at Lyle Falls Fishway.

Passage for summer and winter steelhead at Lyle Falls (RM 2.2 on the Klickitat River) can become difficult during low flow conditions. At low flows, minimal water passes through the fishway, whose exit channel is often shallow with exposed bedload, resulting in fish reluctant to enter and exit the fishway. New fish passage technology provides solutions to remedy problems with the fishway and facilitate increased passage through a wider range of flows, particularly during low flow conditions. Increased passage through a properly functioning fishway will not only facilitate the monitoring of returns and enable the collection of steelhead broodstock for the integrated hatchery program but will also ease steelhead migration.

Actions

- Reconstruct Lyle Falls fishway to Federal design criteria to ease steelhead migration, facilitate the monitoring of returns, and function as a site for broodstock collection for the integrated hatchery program.

Strategy 4. Assess steelhead natural recolonization of upper Klickitat watershed and the potential use of artificial propagation to accelerate recolonization.

In 2005, full anadromous fish passage was restored into the Upper Klickitat watershed as a result of improvements to the Castile Falls Fishway. Analysis conducted by the Yakama Nation and ICTRT indicates that the current habitat potential above Castile Falls could substantially increase the abundance of Klickitat River steelhead once fully seeded. Efforts need to be implemented to adequately assess the natural recolonization of steelhead in the upper watershed and to explore the potential use of artificial propagation as a means to accelerate recolonization.

The Yakama Nation is working with the HSRG, NMFS, WDFW, tribal leaders, BPA, and others to examine whether a conservation hatchery program could be used to accelerate recolonization of the Upper Klickitat watershed (Sharp et al. 2008). The program may also be used to provide harvest opportunities. The need for, and use of, artificial production to accelerate recolonization would be contingent upon the rate and extent that natural recolonization occurs in the upper watershed now that passage has been restored

at Castile Falls. The decision to implement an artificial propagation program would likely imply that natural recolonization has been minimal and/or is occurring at an extremely slow rate.

Actions

- Monitor annual natural escapement of steelhead into the upper subbasin.
- Use Castile Fishway trap to collect biological data on *O. mykiss* migrating into the upper watershed, and to monitor trends in the genetic composition and diversity of the upper basin population.
- Explore need for a conservation hatchery program to accelerate recolonization of upper Klickitat watershed.

Strategy 5. Determine and minimize impacts of hatchery trout releases in the Klickitat subbasin.

The continued release of Goldendale Hatchery trout in the Little Klickitat River should be evaluated by WDFW, because of the potential for adverse interactions with naturally spawning steelhead that are known to escape above the falls. WDFW planting records for 2006 show 5,214 hatchery rainbow trout were released into the upper Little Klickitat River and 844 hatchery rainbow trout were released into Bird Creek, a tributary to Outlet Creek in the Glenwood Valley. Goldendale Hatchery rainbow trout have been cultured to be "fall spawners" to minimize genetic impacts. However competition, predation, disease, and harvest impacts should be evaluated.

Potential evaluations include investigating the use of triploid trout (sterile) releases into streams where steelhead directly reside, or where outplants can colonize downstream. Because of potential for negative interaction, the Yakama Nation releases only triploid hatchery trout in lakes for recreational fisheries within the reservation boundaries. At a minimum, mark all hatchery trout and require release of unmarked juveniles.

Actions

- Investigate impacts of WDFW hatchery trout plants into the Klickitat subbasin.

6.3 Freshwater Habitat Strategies and Actions

This plan proposes a strategy to protect and improve ecosystem functions and restore normative ecological processes. The components of the strategy are, first, to protect and maintain existing high quality and/or unimpaired habitats and ecosystem functions; and, second, to restore degraded habitat where appropriate, through passive and active measures.

- Protection and maintenance of existing high quality habitats is a broad, economical approach to species recovery. Many objectives are likely to be met through habitat protection and the associated natural recovery of upland and riparian areas. Protection and maintenance includes compliance with existing rules and regulations, such as the State Forest Practices Act, Klickitat County

Shorelines Master Plan and Critical Areas Ordinance, and other state and county regulations designed to protect aquatic habitat. Protection may also incorporate a wide range of voluntary actions such as fencing riparian areas, participation in the various agricultural land reserve programs, and voluntarily implementing programs that help to avoid impacts to aquatic resources. Land acquisitions, conservation easements, cooperative agreements, and protective land designations can also be used to facilitate high quality habitat protection.

- Restoration and enhancement of habitat conditions for salmon and steelhead populations should improve population production. The value of these actions to the viability of the population will depend on whether or not they address the factors currently limiting the population or threats associated with factors that are now, or are trending toward, becoming limiting, e.g. climate change. The success of these strategies is further enhanced when actions build from existing restoration efforts and incorporate a range of project types that address the many interrelated habitat impairments related to the limiting factors.

The overall strategy is further differentiated into the following types of action to address potential limiting factors and threats for Klickitat steelhead production: 1) protect stream corridor structure and function; 2) restore passage and connectivity between habitat areas; 3) restore floodplain function and channel migration processes; 4) restore riparian condition; 5) restore altered hydrographs to enhance instream flows during critical periods; and 6) restore degraded water quality, including water temperatures. Finally, more specific management actions are described.

Priority Geographic Areas

Geographical areas within the Klickitat subbasin that may have greater restoration value than others for the health and productivity of Klickitat steelhead were identified through three related efforts: the Northwest Power and Conservation Council's 2004 subbasin planning process; the Klickitat Lead Entity process performed under the Washington State Salmon Recovery Planning process SB2496; and Yakama Nation's 2005 and 2006 EDT model runs (unpublished), which incorporated major spawning areas.

- The purpose of the Northwest Power and Conservation Council's subbasin planning process was to "provide a basin-wide approach to developing locally informed fish and wildlife protection and restoration priorities," and to "bring people together in a collaborative setting to improve communication, reduce conflicts, address problems, and, wherever possible, reach consensus on biological objectives and strategies that will improve coordinated natural resource management on private and public lands." One of the subbasin goals, similar to the broad-sense goal proposed by the Yakama Nation for this recovery plan, was "to restore and maintain sustainable, naturally producing populations of spring Chinook and stelhead that support tribal and non-tribal harvest and economic practices while protecting the biological integrity and the genetic diversity of the subbasin."

The 2004 Klickitat Subbasin Plan ranked geographic areas based on analysis of EDT model outputs of environmental and survival attributes, and the potential benefit to population parameters that the model identified. Various EDT outputs, such as a reach analysis and a breakdown of relative importance of geographic areas for protection and restoration measures (both standard outputs as well as outputs normalized to correct for weighting of reach length), rank population performance parameters by individual life stage, as well as averaged across all life stages.

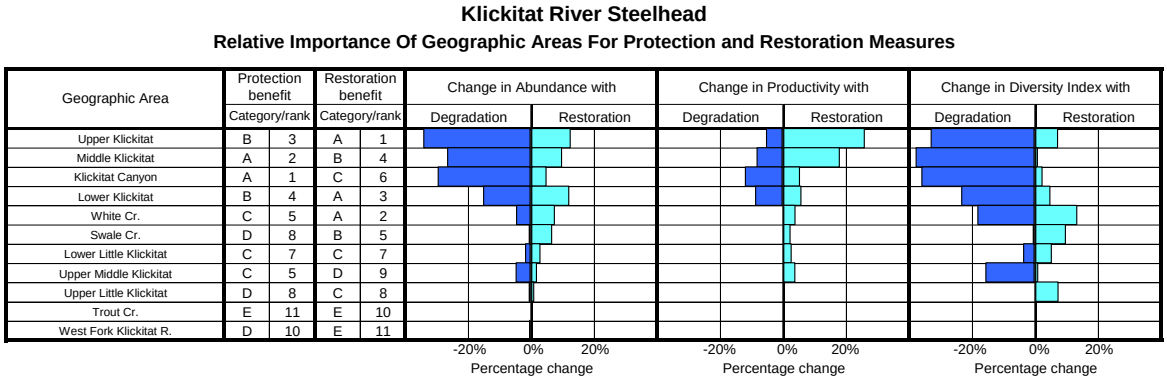
- The Klickitat Lead Entity's Citizens Committee also identified the equivalent of broad-sense goals and, with assistance of the Lead Entity's Technical Committee, identified and prioritized reaches with corresponding habitat and restoration actions for the purpose of prioritizing projects for grant funding and assisting with voluntary conservation efforts of priority basin fish species (steelhead, rainbow trout, mountain whitefish, Chinook salmon, bull trout, etc.). The Klickitat Lead Entity Strategy was developed for use by the Lead Entity Organization for non-regulatory purposes and has not been subject to peer review or other quality assurance processes appropriate for regulatory application of its contents (Klickitat Lead Entity, 2006, 2007, 2008). The Lead Entity Organization developed a matrix of priority areas considering community interests and used a mix of existing data from habitat assessments, fish distribution surveys, and spawning ground surveys, as well as knowledge of professionals familiar with the subbasin. Data sources included published reports from Yakama Nation Fisheries, WDFW, WDOE, consulting firms, as well as unpublished databases maintained by these agencies and professional judgment.

Identification of Potential Projects

Actions to address limiting factors in the Klickitat basin were identified using EDT modeling, other processes, and best professional judgment. The 2005 and 2006 EDT models were also used to identify primary limiting factors by life stage and reach and to rank the relative restoration and protection potential of the six major spawning areas and five minor spawning areas identified by Yakama Nation Fisheries in the Klickitat drainage (Figure 6-1). This information, as well as costs, quantitative and qualitative assessments of project time frames, implementability, time to implement, time to realize benefits and impact of those benefits on limiting factors and VSPs at 10 and 25 years out, were all fed into a custom-built relational database for prioritizing salmon recovery actions in the Klickitat subbasin. It is important to note that the accuracy of any modeling effort depends on the assumptions and information put into the model. This and other modeling will be revisited as more data are collected on habitat conditions in the basin through ongoing and proposed monitoring and research.

The delineations of the spawning areas identified by the Yakama Nation differ from those identified by the ICTRT in a few areas (see Appendix II, Table II-1). Nevertheless, findings from the EDT analysis were useful in developing the suite of freshwater habitat strategies and actions.

Figure 6-1. EDT Estimate of Relative Importance of Major and Minor Spawning Areas for Protection and Restoration Measures for Klickitat Steelhead (2005 YN EDT model analysis, unpublished data).



Freshwater habitat strategies and actions to improve the viability of the Klickitat steelhead population are described in Tables 6-1 through 6-6. The strategies address the key factors and threats potentially limiting population viability and are based on results from EDT analysis and other assessments, including the ICTRT's viability assessment for the populations. [3]

Primary freshwater actions identified for steelhead focus on restoring ecological functions in the watershed. These actions include: increasing floodplain channel and roughness, reconnecting side-channels, improving floodplain connectivity, relocating floodplain infrastructure and roads, improving maintenance, rehabilitating and decommissioning roads as appropriate, re-establishing and/or enhancing native vegetation within floodplain, implementing practices that leaves naturally occurring sources of large woody debris instream, and/or artificially introduce large debris or other structure. The tables also identify priority locations where implementation of actions under each strategy will reap the greatest benefits.

Results from Ecosystem Diagnosis and Treatment (EDT) modeling in 2005 by Yakama Nation Fisheries (unpublished) provide some indication of the change in steelhead production that might be expected to occur if all historical habitat areas above Castile Falls were fully seeded. The modeling effort measured intrinsic productivity, equilibrium abundance, and capacity of the system for steelhead within spawning locations defined by resource specialists. Two scenarios were developed: 1) full blockage, with Castile Falls completely blocking upstream fish passage — as was the case from the early 1960s until modifications were completed in 2005 — and 2) full passage, with 100 percent passage at Castile Falls and assuming that all habitat above it had been fully seeded with anadromous fish (currently passage is open, but the area is only beginning to be re-colonized, a process that might require years to fully take place unaided).

[3] Tables 6-1 through 6-6 were not developed through the Klickitat Lead Entity Strategy or the Lead Entity process.

Modeling results for the full blockage scenario suggest that the theoretical intrinsic productivity (current with harvest) of the system with no passage above Castile is 3.6, and equilibrium abundance is 1,064 steelhead. In contrast, under the full passage scenario, with 100 percent passage and habitat seeding above Castile, intrinsic productivity increased to 3.7 and equilibrium abundance to 1,628. The potential increase in capacity of fully opening habitat above Castile rose from 1,475 to 2,222 steelhead. These EDT projections, however, do not represent the return for any given year, but rather the potential return if the population is not limited by density-dependent factors, natural disasters or other mortality factors. The projections represent the potential for a population to recover when conditions improve. It is possible that some factors might be under- or overestimated. It is always necessary to adjust the results after comparing with actual observations, other data, and expert opinion.

Table 6-1. Strategy 1: Protect Stream Corridor Structure and Function.

Protect stream corridor structure and function					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
a) Protect existing habitat from future degradation through conservation easements, acquisitions, reclassification of lands as natural areas, enforcement of land use regulations. b) Riparian forest management and planning: plan to leave buffer strips in riparian forest zones. c) Limit riparian livestock grazing. d) Assess effects of groundwater development on tributary flow. e) Manage diversions to maximize instream summer flows.	Many factors, including key habitat quantity, habitat diversity, sediment load, water quality, altered flow regimes, predation	Floodplain infrastructure; timber, agricultural and grazing practices; habitat fragmentation due to land development	Productivity, abundance, spatial structure	All	Protecting functioning floodplains and channels that are in balance with their ability to transport water and sediment is one of the highest priorities. All streams will have some level of erosion, because a stream channel is never static. Having some erosion is essential for recruitment of spawning gravel and other important ecological functions (such as distributing fine sediments needed for riparian plant growth). Existing quality habitat may be protected through land acquisition and/or conservation easements by WDFW or a land trust. WDNR parcels that are currently in State Lands in the upper Klickitat could be reclassified as Natural Areas. Protecting base stream flows from further appropriations is a very important function of protecting existing high quality habitats.
Priority Locations (geographic areas)					
Mainstem Klickitat and throughout MaSA watersheds. Highest priorities: Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek.					

Table 6-2. Strategy 2: Restore Passage and Connectivity between Habitat Areas.

Restore passage and connectivity between habitat areas					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
a) Replace culverts. b) Monitor effectiveness of passage improvements at Castile Falls. c) Improve passage at Lyle Falls. d) Study passage at mouths of spawning tributaries relative to flow and alluvial fan morphology. e) Monitor and continue restoration efforts in Snyder Creek mill reach (flume passage improvements and riparian re-vegetation.) f) Determine extent of problem for inadequately screened intakes. g) Ensure that pump intakes are adequately screened.	Passage obstructions, altered flow regimes, key habitat quantity, water withdrawals	Inundation by Bonneville Pool, undersized/ inadequate culverts, irrigation diversions, instream structures, past riparian logging and stream cleaning, floodplain infrastructure, insufficient flow at tributary mouths	Spatial structure, abundance, productivity	All, particularly adults and age 0-2 juveniles	Partial-barrier culverts exist near the mouth and upstream on Piscoe Creek, near the mouth of McCreedy Creek, and on some Little Klickitat tributaries (numerous), on White Creek and its tributaries limiting upstream movement of juveniles from rearing habitat to perennial refugia. Passage at mouths of some tributaries restricts access to spawning areas due to alterations in flow and alluvial fan morphology (research is needed). Steelhead and spring Chinook are expected to begin re-colonizing spawning and rearing habitat above Castile Falls now that passage has been improved; monitoring of effectiveness of passage improvements is needed. Disconnecting roads can improve watershed and water retention.

Restore passage and connectivity between habitat areas					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Priority Locations (geographic areas)					
Piscoe Creek, McCreedy Creek, White Creek and tributaries, Little Klickitat tributaries, upper Klickitat mainstem, West Fork Klickitat, Trout Creek. Highest priorities: Castile Falls and culverts on several tributary streams					

Table 6-3. Strategy 3: Restore Floodplain Function and Channel Migration Processes.

Restore floodplain function and channel migration processes					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
a) Place LWD or other structures to stop headcutting. b) Restore stream length. c) Restore cross-sectional morphology and roughness. d) Augment gravel. e) Increase pool quantity and quality; pool: riffle ratio. f) Improve pool cover and hiding refugia. g) Restore floodplain and side-channel connectivity. h) Increase floodplain and channel roughness. i) Re-vegetate riparian areas. j) Relocate/ soften floodplain infrastructure. Modify historical railroad grade. k) Disconnect roads from stream network to improve watershed and water retention. l) Improve surface and drainage characteristics of roads in tributary watersheds. m) Perforate roads to allow peak flows to move onto floodplain. n) Relocate/ abandon mid-slope roads where possible; relocate/abandon valley-bottom roads where possible. o) Close/relocate ORV trails. p) Limit riparian livestock grazing. q) Investigate off-channel livestock watering. r) Promote no-till cropping and riparian buffers in agricultural areas, s) Modify land-uses and/or implement structures to retain storm flow and decrease time of concentration from watershed upstream of canyon (Swale Creek).	Habitat diversity, key habitat quantity, sediment load, altered flow regimes, altered food web, water temperature, predation	Hydroconfinement; floodplain infrastructure; timber and grazing management activities; habitat fragmentation due to subdivision, land-clearing and development	Productivity, abundance, spatial structure	All	There has been a loss of off-channel and side-channel habitats that once provided habitat for spawning and rearing, and refugia from high flows. Instream structures can improve channel stability, trap sediments and raise the stream bed so that the stream can more effectively interact with the floodplain. Typical structures include debris jams, rootwads, boulder clusters, whole trees, and rock weirs where appropriate. Any restoration actions will be ineffectual unless floodplain clearing and grading can be restricted, regulated or eliminated.

Restore floodplain function and channel migration processes					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
Priority Locations (geographic areas)					
Highest priorities: Chaparral Creek, Coyote Creek, McCreedy Creek, Butte Meadows Creek, Klickitat R. from Castle Falls (RM 65.75) to RM 87.05, upper Diamond Fork					

Table 6-4 Strategy 4: Restore Riparian Condition.

Restore riparian function and condition.					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
a) Re-vegetate riparian areas. b) Limit riparian livestock grazing. c) Monitor and continue restoration efforts in Snyder Creek mill reach (flume passage improvements and riparian re-vegetation.) d) Investigate off-channel livestock watering. e) Control/eradicate noxious invasive plant species from priority habitats..	Habitat diversity, key habitat quantity, sediment load, altered flow regimes, altered food web, water temperature	Floodplain infrastructure; timber and grazing management activities; habitat fragmentation due to subdivision; channel incision	Productivity, abundance, spatial structure	All	Primary methods of riparian enhancement include riparian corridor fences to exclude livestock, changes in grazing management that promote riparian recovery, and planting of native vegetation. The ecological effects of restoration actions include increased floodplain roughness, bank stability, nutrients and recruitment opportunity for future large wood.
Priority Locations (geographic areas)					
Trout Creek, Upper Little Klickitat, Lower Little Klickitat, Klickitat Canyon, Swale Creek, Lower Klickitat, Middle Klickitat, White Creek, Upper Klickitat. Highest priorities: Chaparral Creek, McCreedy Creek, Piscoe, Diamond Fork, Coyote, Butte Meadows, Klickitat R. from Castile Falls (RM 65.75) to RM 87.05					

Table 6-5. Strategy 5: Restore Altered Hydrographs to Enhance Instream Flows during Critical Periods.

Enhance instream flow during critical periods.					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
a) Obtain instream flow right for mainstem Klickitat. b) Restore floodplain connectivity in tributaries. c) Assess effects of groundwater development on tributary flow. d) Manage diversions to maximize instream summer flows. e) Re-introduce beaver.	Habitat diversity, key habitat quantity, sediment load, altered flow regimes, water temperature, water withdrawals	Floodplain infrastructure; road, timber, agricultural and grazing management activities; hydroconfinement; water withdrawals, beaver removal	Abundance, productivity, spatial structure	All, particularly 0-1 age life stages	Hydrologic routing in watershed has been modified, and flow timing, discharge, distribution of LWD and sediment altered. Shortened flow paths for storm flow, changes associated with reduced canopy interception, and changes in the upland plant community due to land management have reduced precipitation infiltration rates, resulting in higher peak flows and lower base flows. Removal of large wood, reduced ability for large wood recruitment and

Enhance instream flow during critical periods.	
	incision in streams also increases water velocities and reduces the ability of the stream to hold water for gradual release.
Priority Locations (geographic areas)	
Lower Klickitat, Middle Klickitat, Lower Little Klickitat, Upper Little Klickitat, White Creek, Trout Creek, Swale Creek Highest priorities: streams in the lower and middle Klickitat watersheds, including Knight Canyon, Dillacort, Wheeler, upper Canyon, Beeks Canyon, and Dead Canyon creeks, and portions of White Creek.	

Table 6-6. Strategy 6: Restore Degraded Water Quality, including Water Temperatures.

Restore degraded water quality, including water temperatures.					
Actions	**Limiting Factors Addressed**	**Threats Addressed**	**VSP Parameters Addressed**	**Life Stages Affected**	**Discussion**
See actions for Strategy 3. a) Short-term fertilization of stream with carcasses or carcass analogs. b) Improve road drainage characteristics and surfacing. c) Re-vegetate riparian areas to reduce stream temperatures. d) Conduct pathogen sampling and monitoring. e) Investigate off-channel livestock watering f) Assess nutrient and dissolved oxygen levels in the Little Klickitat River, particularly downstream of Goldendale.	Sediment load, altered flow regimes, water temperature, water quality, altered food web, pathogens	Road, timber and grazing management activities, particularly in riparian areas; incision	Abundance, productivity, spatial structure	All life stages	Riparian vegetation is limited in many parts of the drainage. Roads and other infrastructure have altered floodplain, confined river and tributaries and contribute fine sediment to stream channel. Loss of LWD and other structure limits availability of pools and other thermal refugia. Reduced sediment inputs will increase aquatic insect production for food. Carcasses will provide temporary food source for juveniles.
Priority Locations (geographic areas)					
Highest priorities: Klickitat River from RM 70.5 to RM 87.05, Chaparral Creek, Diamond Fk., Piscoe Creek					

6.4 Harvest-Related Strategies and Actions

WDFW will continue to manage Klickitat tributary sport fisheries for selective fisheries that target marked hatchery summer steelhead. Tributary fisheries will be managed under a Fisheries Management and Evaluation Plan for Middle Columbia River steelhead submitted to NMFS by WDFW, which is currently going through NMFS review. Columbia River mainstem harvest of steelhead will continue to be managed through the *U.S. v. Oregon* process, and will be subject to consultations with NMFS. Enhanced public education and fisheries enforcement will be incorporated along with new selective fisheries regulations to ensure understanding and compliance.

Treaty Native American fishing rights in the Columbia basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon*, No. 68-513 (filed in 1968). The parties to *U.S. v. Oregon* are the United States acting through the Department of Interior (USFWS and Bureau of Indian Affairs) and Department of Commerce (NMFS), the Warm Springs, Umatilla, Nez Perce, Yakama, and Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho. In *U.S. v. Oregon*, the Court affirmed that the treaties reserved for the tribes 50 percent of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas.

Starting in 1977, tribal and state fisheries subject to *U.S. v. Oregon* have been regulated pursuant to a series of court orders reflecting court-approved settlement agreements among the parties. The last long-term agreement, known as the Columbia River Fishery Management Plan (CRFMP) was adopted and approved by the Court in 1988 and expired in 1999. Since 1999, Columbia River mainstem fisheries have been managed via short term settlement agreements adopted by the Court. Artificial propagation programs upstream of Bonneville Dam have also been incorporated into these agreements, because of their importance to providing fish for harvest. Harvest plans for tributary fisheries are developed cooperatively by the management entities with primary management responsibility in the respective subbasin. A new *U.S. v Oregon* Management Agreement has been completed and NMFS has completed a Section 7 Biological Opinion addressing the impacts of the fisheries management action and hatchery production in the new agreement (https://pcts.nmfs.noaa.gov/pls/pcts-pub/biop_results_detail?reg_inclause_in=('NWR')&idin=107547). The new management agreement will cover Columbia River fisheries management and hatchery production actions for the period from 2008 to 2017.

During the last 10-15 years, harvest has been managed pursuant to the CRFMP and successor agreements that contain restraints on the fisheries necessitated by ESA listings. The agreements quantify and allocate harvest between tribal and non-tribal fishing subject to ESA-imposed constraints for listed species. The current *U.S. v. Oregon* harvest constraint for steelhead is set to protect Group "B" index fish returning to Idaho with impacts from Non-Native American fisheries limited to 2 percent and tribal fisheries to 15 percent. Group "A" index fish (including those returning to the Klickitat River) are affected by tribal fisheries at a substantially lower rate than Group "B" index fish. The

new agreement sets an impact limit on naturally produced Mid-Columbia River steelhead of no more than 2 percent in non-treaty fisheries but does not set a limit for treaty fisheries. However, NMFS expects impacts from the treaty fisheries to continue to be in the range observed since 1998, averaging around 6.64 percent.

In 2002, WDFW instituted a sport fishing rule change for the Klickitat River proposed by the Yakama Nation. The rule change closed fishing for rainbow trout in lower subbasin tributaries of the Klickitat River (Swale, Wheeler, and Snyder Creek). The purpose was to protect rearing steelhead juveniles from take and harassment.

Strategy 1. Study and limit impacts of harvest practices on Klickitat steelhead population.

Enforcement of sport and tribal fishing regulations and control of illegal fishing on and off the reservation is a priority. Poaching and harassment of steelhead in the Klickitat subbasin occurs at an unknown rate.

Actions

- Enforce tribal and sport regulations to eliminate illegal harvest.

6.5 Mainstem Columbia Hydrosystem and Estuary -- Strategies and Actions

The plan for current mainstem hydro operations, as summarized in the Hydro Module (NMFS 2008c), and any further improvements for fish survival that may result from the ongoing Federal Columbia River Power System (FCRPS) collaborative process, represent the hydropower recovery strategy for all listed salmonids that migrate through the mainstem Columbia River, including the Middle Columbia steelhead populations.

The Hydro Module summarizes the general effects of Columbia River mainstem hydropower projects on all 13 ESA-listed salmonids in the Columbia basin, including the limiting factors and threats and expected actions (including site-specific management actions), or strategy options, to address those threats. This module is a synthesis of information that has undergone public processes for review, including, but not limited to, the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (NMFS 2008b), Federal Energy Regulatory Commission (FERC) licensing proceedings, and Habitat Conservation Plans (HCPs). It may be updated as additional information becomes available.

The Reasonable and Prudent Alternative (RPA) for the FCRPS (2008b) takes a comprehensive approach to ESA protection that includes hydro, habitat, hatchery, harvest and predation measures to address the biological needs of salmon and steelhead in every life stage. The RPA is the product of the collaboration between NMFS and the Action Agencies ordered by the court. It is based on a comprehensive analysis of the salmon life cycle conducted down to the level of the populations that make up the listed species. Section 8.8 and the "Reasonable and Prudent Alternative Table" in the 2008 FCRPS

Biological Opinion describe actions that should positively affect Middle Columbia River steelhead.

The current plan for operation of the FCRPS through 2018 (NMFS 2008a) contains the following actions intended to address the needs for survival and recovery of ESA-listed salmon and steelhead:

- Continue adult fish passage operations that have resulted in improved survival.
- Improve juvenile fish passage: install removable spillway weirs or similar surface bypass devices at John Day and McNary dams, an extended tailrace spill wall at The Dalles Dam, and various modifications at Bonneville Dam. Passage for steelhead smolts at each of the four Lower Columbia River mainstem projects must reach 96 percent survival.
- Continue and enhance spill for juvenile fish passage.
- Continue reservoir operations and river flows to benefit spring migrating juveniles.
- Develop dry water year operations to better protect migrating juveniles.
- Develop and implement a kelt management plan.

The Estuary Module, which NMFS prepared in collaboration with the Lower Columbia Estuary Partnership (NMFS 2007), focuses on habitat in the lower Columbia River below Bonneville Dam and how that habitat affects the survival of ESA-listed chum, steelhead, Chinook, and coho from throughout the Columbia River basin. It identifies and prioritizes limiting factors and threats in the estuary, then identifies 23 broad actions whose implementation would reduce the threats and thus increase survival of salmon and steelhead during their time in the estuary. The module also estimates the cost of implementing each action over a 25-year period. A description of monitoring, research, and evaluation needs that are appropriate to the management actions is included as an appendix to the module.

6.6 Potential Effects of Proposed Recovery Actions

This section presents an analysis of the potential effects of proposed recovery actions on the abundance and productivity of the Klickitat population of Middle Columbia River steelhead, based on the 2005 and 2006 EDT modeling done by Yakama Nation Fisheries (unpublished). Estimated levels of effectiveness for the proposed actions were generated and used as inputs into quantitative models to project the potential impacts of those changes on the population. This quantitative analysis provides an opportunity to evaluate the efficacy of proposed recovery strategies in light of current knowledge regarding population functioning, including relationships with habitat conditions. Equally important, the quantitative models used in the assessment provide a framework for productively targeting evaluation efforts as well as for revisiting key assumptions in the

future as more information becomes available (e.g., from monitoring responses to initial implementation or from evaluation efforts targeting key uncertainties).

The analysis was performed sequentially, first by projecting effects for tributary habitat actions alone, then sequentially adding in hatchery, hydro, predation, estuary, and harvest actions. The results at each step provide a means for comparing estimated relative benefits of the proposed suites of actions, and, finally, the potential benefit of all the proposed actions to the Klickitat steelhead population.

Two models were used: Ecosystem Diagnosis and Treatment (EDT) and the All-H-Analyzer (AHA). The EDT model has commonly been used in regional planning efforts to evaluate potential responses to tributary habitat restoration efforts. The EDT model uses derived relationships between habitat characteristics and fish survival to calculate changes in survival, abundance, and productivity that could result from changes in the habitat. Use of the EDT model requires a set of inputs that describe current habitat conditions and the expected changes in habitat conditions that would result from a proposed action scenario. This model could be used, for example, to calculate the improvement that would be expected from a 10 percent drop in water temperature during the period of egg incubation in a certain tributary reach. The AHA model encompasses prospective relationships between all the "H" factors: habitat, hatcheries, hydro, and harvest. Thus, the results of the EDT model become one set of information fed into the AHA model to produce an estimate of the benefits of all the proposed actions.

It is important to note that the modeling results relative to recovery criteria are a function of the input information and key assumptions associated with the translation of actions into habitat changes, habitat and life-stage survival relationships, and population dynamics. Although the modeling provides valuable insight into the potential responses to recovery actions, the estimated potential responses are dependent on the assumptions and information put into the models.

Abundance and productivity are projected to increase for all scenario combinations analyzed for Klickitat River steelhead (Table 6-7; note that performance values in the table are direct output from EDT/AHA). The largest contribution to performance improvements results from the combination of tributary habitat actions throughout the basin and recolonization of the upper watershed (recolonization of the upper watershed is possible because of passage improvements at Castile Falls). In contrast, relatively small increases are attributable to mainstem actions.

Table 6-7 shows estimated population performance (productivity and abundance) of Klickitat River steelhead associated with combinations of all priority tributary and out-of-subbasin actions. Population performance measures are directly from EDT/AHA and were not converted to ICTRT-equivalent performance values (the ICTRT was unable to empirically estimate baseline performance measures for this population because of a lack of data). Results are shown with and without recolonization of the upper watershed. All scenario combinations include average ocean conditions (average during baseline and current conditions); ocean ±25% represents performance of combined actions under

relatively poor and good ocean conditions. Scenarios were run in a stepwise fashion, starting with baseline, then current conditions, and then adding in actions sequentially, each being added to the previous scenario.

Table 6-7. Estimated Productivity and Abundance of Klickitat River Steelhead Associated with Combinations of all Priority Tributary and Out-of-Subbasin Actions.

Performance period	Scenario combination	Performance metric			
		Productivity		Abundance	
		Actions without recolonization of upper watershed	Actions with recolonization of upper watershed	Actions without recolonization of upper watershed	Actions with recolonization of upper watershed
Base		1.77		939	
Base-Current		1.92	1.92	1,118	1,118
Current-Prospective	Habitat	2.12	2.38	1,319	2,320
	Hydro	2.24	2.50	1,468	2,572
	Predation	2.29	2.56	1,538	2,692
	Estuary	2.36	2.62	1,630	2,850
	Harvest	2.36	2.62	1,630	2,850
	Ocean ±25%	2.01-2.64	2.27-2.90	1,181-2,026	2,088-3,539

This is a rough estimate, given the current data gaps and uncertainties, useful simply as an indication that if recovery actions are implemented, the population is likely to trend toward viable status. As we learn more about this population, implement proposed actions, and improve modeling methods, the analysis will be refined.

7. Implementation and Preliminary Cost Estimates

NMFS recognizes that there are significant uncertainties about the underlying biology and the best approaches to improving conditions for steelhead. NMFS is committed to an ongoing effort to address these uncertainties and work through associated disagreements over management approaches as part of implementing this recovery plan. This will require rigorous application of an adaptive management process that identifies key uncertainties, proposes competing hypotheses, and uses recovery actions and appropriate research and monitoring to test these hypotheses and adjust management accordingly.

Implementation of this plan depends on the voluntary actions and cooperation of local entities and citizen groups. An important part of implementation will be working cooperatively to develop a detailed research, monitoring, and evaluation plan addressing the additional information needs described in Chapter 8. It will be essential that a collaborative implementation structure be set up to improve communication and work on a shared sense of priorities.

7.1 Implementation

NMFS has worked independently with the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, and other local entities to develop the recovery plan for the Klickitat steelhead population. NMFS encourages the formation of a planning group for the Washington Gorge Management Unit, a forum or entity that would take responsibility for coordinating implementation of the plan. Implementing the proposed recovery actions for steelhead in the Washington Gorge Management Unit, including the Klickitat subbasin, would be a primary task for a Washington Gorge Area Regional Board, subject to concurrence by state, tribal and local governments and the opportunity for involvement and comment by the public.

The Washington Gorge Area Regional Board could consist of representatives from Klickitat, Yakima and Benton counties, local landowners, and the Yakama Nation. The Board could also provide an opportunity for coordination with the Lower Columbia River Fish Recovery Board (LCFRB), since the Washington Gorge Management Unit includes both the Middle Columbia River Steelhead DPS and the Willamette/Lower Columbia ESUs for Chinook, coho, and chum ESA-listed populations, which are covered by the LCFRB.

The Washington Gorge Area Regional Board could use the considerations identified in Chapter 6 to prioritize recovery actions in the Klickitat subbasin and other areas within the Washington Gorge Management Unit to respond to the interests identified by various stakeholders in the area.

The prioritization of projects for funding should be based on a balance between the biological benefit of the project, its cost, and feasibility of implementation. Projects that

address primary limiting factors, have high biological benefit, are relatively inexpensive, and are feasible should receive highest funding priority. Projects that have high cost, low biological benefit to listed fish species, and relatively low feasibility should receive lowest funding priority.

Funding sources for salmon and steelhead recovery actions in the Columbia Basin are varied. They include:

- Pacific Coastal Salmon Recovery Fund (PCSRF) (states and tribes)
- Salmon Recovery Funding Board (SRFB) (a combination of PCSRF and Washington State funds)
- Columbia Basin Fish Accords
- Congressional appropriations (Federal agencies)
- State appropriations (state agencies)
- Northwest Power and Conservation Council Fish and Wildlife Program (states and tribes)
- Federal / state grants
- Non-profit organization programs and grants

The 2008 Columbia River Fish Accords Memorandum of Agreement (MOA) between the Three Treaty Tribes and FCRPS Action Agencies (Columbia Basin Accords 2008) identifies funds for hatchery planning and operations and maintenance covering some of the existing and expanded activities in the Klickitat River basin. The MOA identifies hatchery capital funds for the design and construction of the hatchery and passage facilities in the Klickitat River basin except the Wahkiacus Hatchery facility, and includes language that states that the Action Agencies will work toward finding funding for this facility.

7.2 Preliminary Cost Estimates

Preliminary cost estimates are provided for the three major categories of strategies and actions: RM&E, hatcheries, and habitat. The highest priority strategies for the Klickitat basin address data gaps (see Section 6-1). As such, these priority strategies fall into the category of research, monitoring, and evaluation. The costs associated with these efforts are detailed in Chapter 8. Table 8-1 estimates the cost of ongoing and expanded RM&E activities to be up to $4,484,402 for years 1 through 3, and up to $15,142,783 for years 4 through 10. Information gained through filling the priority data gaps will help to refine the actions needed to reach recovery.

Costs for actions to address hatchery-related effects are distributed among research, monitoring and evaluation, detailed in Chapter 8, and capital costs and operations and maintenance costs that have been included in programs proposed under the NPCC Fish and Wildlife Program or are ongoing under that program or the Mitchell Act administered by NMFS. Capital costs for hatchery and fish passage improvements are shown in Table 7-1, which is drawn from the Klickitat River Anadromous Fisheries Master Plan. The plan was submitted by the Yakama Nation to the NPCC to fulfill the requirements for step one of a three-step process for the approval of major projects

(Sharp et al. 2008). The costs are estimated based on the current status of the design and may change as the design is finalized. Since these operations and maintenance costs are ongoing, they were not included in the future costs of recovery actions (Plummer 2006).

Table 7-1 Klickitat Subbasin capital construction costs estimates in FY07 dollars (Sharp et al. 2008).

Description	Estimated Cost
Lyle Falls Fishway Passage Improvements and R, M&E Station	$5,750,000
Castile Falls Enumeration Facility	$1,149,000
Klickitat Hatchery Infrastructure Upgrades with Reform Measures[4]	$16,100,000
McCreedy Creek Steelhead (Conservation) Acclimation Site	$234,000
Wahkiacus Hatchery & Acclimation Facility Construction[5]	$18,400,000
TOTAL	*$41,633,000*

Habitat recovery actions, estimated costs, and time frames based on current information are listed in Table 7-2. The cost estimates are based on a number of efforts: the recommendations and priorities from the NPCC subbasin planning process; expert opinion of resource professionals working in the watershed; local knowledge; current cost estimates of YN project dollars (e.g., Klickitat Watershed Enhancement Project activities); and land values derived in conjunction with the Columbia Land Trust. It should be noted that the habitat cost estimates below are for Yakama Nation-defined MaSAs. For correlation with the ICTRT-defined MaSAs, see Appendix II, Table II-1.

The total estimated cost for completing all of the habitat projects identified inTable 7-2 is estimated to be up to $129,451,630 ($25,890,326.00 for years 1-10, and $103,561,304.00 for years 11-50). Estimates are expressed in 2007 dollars. Estimated costs are general range summaries arranged to align with the Klickitat River Anadromous Fisheries Master Plan (Sharp et al. 2008) and Yakima/Klickitat Fisheries Project.

The actions listed in Table 7-2 do not include or account for out-of-subbasin effects or future degradation or damage to the watershed.

[4] In July 2009, BPA initiated the EIS process for the Klickitat Hatchery Program and Step III of the Klickitat River Anadromous Fisheries Master Plan, with an anticipated final EIS document in early 2011.

[5] Fish Accord Agreement language states that the Action Agencies will work toward finding funding for the Wahkiacus Hatchery Facility (Columbia Basin Accord 2008, Attachment B).

Table 7-2. Habitat actions and costs for Klickitat steelhead by Major and Minor Spawning Areas.

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
Upper Klickitat MaSA	Fish Passage - Culvert Replacement	# of installations	7	$100,000	$700,000
	Instream - Streambank Stabilization	length treated in miles	2	$100,000	$200,000
	Instream - Channel Connectivity	length treated in miles	12	$65,000	$780,000
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	4	$475,200	$1,900,800
	Instream - Deflectors/ barbs	length treated in miles	1	$35,000	$35,000
	Instream - Off channel habitat	length treated in miles	1	$105,600	$105,600
	Instream - Spawning Gravel Placement	length treated in miles	1	$90,000	$90,000
	Instream - Log (control) weirs	# of structures	10	$2,500	$25,000
	Instream - Rock (control) weir	# of structures	14	$2,500	$35,000
	Instream - Large Woody Debris	# of structures	20	$1,000	$20,000
	Instream - Structure/ Log Jam	# of structures	125	$15,000	$1,875,000
	Instream - Beaver Introduction	# of beavers introduced	20	$350	$7,000
	Riparian - Livestock Water Development	# of installations	3	$6,000	$18,000
	Riparian - Water Gap Development	# of installations	0	$1,200	$0
	Riparian - Fencing	miles	25	$10,000	$250,000
	Riparian - Planting	species; area treated (acres)	200	$2,000	$400,000
	Riparian - Weed Control	species; area treated (acres)	200	$1,000	$200,000
	Sediment Reduction - Road Reconstruction	miles			
	Sediment Reduction - Road Relocation	miles	8	$120,000	$960,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	4	$1,800	$7,200
	Sediment Reduction - Road Drainage System Improvements	miles	60	$6,000	$360,000
	Sediment Reduction - Road Obliteration	miles	1	$7,000	$7,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Sediment Reduction - Erosion Control Structures	# of erosion structures	15	$1,400	$21,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	60	$600	$36,000
	Upland- Agriculture - Fencing	miles	2	$8,800	$17,600
	Upland- Agriculture - Water Development	# of installations	3	$2,400	$7,200
	Upland- Vegetation - Planting	area treated (acres)	35	$2,000	$70,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	20	$250	$5,000
	Upland- Vegetation - Slope Stabilization	area treated (acres)	80	$180	$14,400
	Land Protected, Acquired, or Leased - Streambank Protected	miles	4	$320,000	$1,280,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	10	$4,000	$40,000
	Nutrient Enrichment - Carcass Placement	area treated (acres)			
	Project maintenance - Site Maintenance	miles	12	$4,000	$48,000
					$9,514,800
White Creek MaSA	Fish Passage - Culvert Replacement	# of installations	9	$100,000	$900,000
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	14	$475,200	$6,652,800
	Instream - Spawning Gravel Placement	length treated in miles	5	$90,000	$450,000
	Instream - Large Woody Debris	# of structures	150	$1,000	$150,000
	Instream - Structure/ Log Jam	# of structures	150	$15,000	$2,250,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Water Gap Development	# of installations	3	$1,200	$3,600
	Riparian - Fencing	miles	6.5	$10,000	$65,000
	Riparian - Planting	species; area treated (acres)	400	$2,000	$800,000
	Riparian - Weed Control	species; area treated (acres)	2	$1,000	$2,000
	Sediment Reduction - Road Reconstruction	miles	4	$8,000	$32,000
	Sediment Reduction - Road Relocation	miles	12	$60,000	$720,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
Middle Klickitat MaSA	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.1	$950,400	$95,040
	Sediment Reduction - Road Drainage System Improvements	miles	50	$6,000	$300,000
	Sediment Reduction - Road Obliteration	miles	5	$7,000	$35,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	50	$1,400	$70,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	40	$600	$24,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	40	$250	$10,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	2	$160,000	$320,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	15	$4,000	$60,000
	Project maintenance - Site Maintenance	miles	14	$4,000	$56,000
					$12,998,940
	Fish Passage - Culvert Replacement	# of installations	1	$250,000	$250,000
	Instream - Channel Connectivity	length treated in miles	4.5	$475,200	$2,138,400
	Instream - Off channel habitat	length treated in miles	2.5	$422,400	$1,056,000
	Instream - Spawning Gravel Placement	length treated in miles	1	$90,000	$90,000
	Instream – Large Woody Debris	# of structures	25	$1,000	$25,000
	Instream - Structure/ Log Jam	# of structures	45	$35,000	$1,575,000
	Riparian - Fencing	miles	2	$10,000	$20,000
	Riparian - Planting	species; area treated (acres)	110	$5,000	$550,000
	Riparian - Weed Control	species; area treated (acres)	30	$1,600	$48,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.05	$950,400	$47,520
	Sediment Reduction - Road Drainage System Improvements	miles	15	$6,000	$90,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
Lower Klickitat MaSA	Sediment Reduction - Road Obliteration	miles	13	$80,000	$1,040,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	60	$1,400	$84,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	35	$600	$21,000
	Upland- Vegetation - Planting	area treated (acres)	1280	$450	$576,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	20	$1,600	$32,000
	Upland- Vegetation - Slope Stabilization	area treated (acres)	10	$1,800	$18,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	2	$640,000	$1,280,000
	Project maintenance - Site Maintenance	miles	15	$8,000	$120,000
					$9,060,920
	Fish Passage - Culvert Replacement	# of installations	1	$350,000	$350,000
	Instream - Channel Connectivity	length treated in miles	0.9	$844,800	$760,320
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	2	$1,161,600	$2,323,200
	Instream - Deflectors/ barbs	length treated in miles	35	$35,000	$1,225,000
	Instream - Off channel habitat	length treated in miles	0.4	$1,161,600	$464,640
	Instream - Spawning Gravel Placement	length treated in miles	2.5	$90,000	$225,000
	Instream - Log (control) weirs	# of structures	10	$2,500	$25,000
	Instream - Rock (control) weir	# of structures	8	$2,500	$20,000
	Instream - Structure/ Log Jam	# of structures	25	$45,000	$1,125,000
	Riparian - Water Gap Development	# of installations	4	$1,200	$4,800
	Riparian - Planting	species; area treated (acres)	320	$4,500	$1,440,000
	Riparian - Weed Control	species; area treated (acres)	80	$1,600	$128,000
	Sediment Reduction - Road Drainage System Improvements	miles	15	$4,200	$63,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Sediment Reduction - Road Obliteration	miles	3.5	$60,000	$210,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	15	$1,400	$21,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	35	$600	$21,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	120	$1,600	$192,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	4	$800,000	$3,200,000
	Project maintenance - Site Maintenance	miles		$4,000	
					$11,797,960
Swale Creek MiSA	Instream- Wetland - Wetland Restoration	area treated (acres)	3200	$5,000	$16,000,000
	Instream - Channel Connectivity	length treated in miles	1.2	$475,200	$570,240
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	17	$950,400	$16,156,800
	Instream - Spawning Gravel Placement	length treated in miles	8.5	$90,000	$765,000
	Instream - Structure/ Log Jam	# of structures	55	$15,000	$825,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Planting	species; area treated (acres)	250	$2,000	$500,000
	Riparian - Weed Control	species; area treated (acres)	250	$1,600	$400,000
	Sediment Reduction - Road Drainage System Improvements	miles	4	$2,200	$8,800
	Sediment Reduction - Road Obliteration	miles	4	$60,000	$240,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	25	$1,400	$35,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	40	$600	$24,000
	Upland- Vegetation - Planting	area treated (acres)	800	$450	$360,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	800	$1,600	$1,280,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	17	$320,000	$5,440,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	50	$4,000	$200,000
	Project maintenance - Site Maintenance	miles	17	$4,000	$68,000
					$42,876,340
Klickitat Canyon MiSA	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.1	$316,800	$31,680
	Sediment Reduction - Road Drainage System Improvements	miles	55	$4,500	$247,500
	Sediment Reduction - Road Obliteration	miles	2	$15,000	$30,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	50	$1,400	$70,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	35	$600	$21,000
	Project maintenance - Site Maintenance	miles	55	$4,000	$220,000
					$620,180
Lower Little Klickitat MiSA	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	6	$844,800	$5,068,800
	Instream - Spawning Gravel Placement	length treated in miles	3	$90,000	$270,000
	Instream - Large Woody Debris	# of structures	20	$1,000	$20,000
	Instream - Structure/ Log Jam	# of structures	18	$15,000	$270,000
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Planting	species; area treated (acres)	160	$2,000	$320,000
	Riparian - Weed Control	species; area treated (acres)	20	$1,600	$32,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	0.1	$950,400	$95,040
	Sediment Reduction - Road Drainage System Improvements	miles	10	$4,500	$45,000
	Sediment Reduction -	# of erosion	35	$1,400	$49,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Erosion Control Structures	structures			
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	20	$600	$12,000
	Upland- Vegetation - Planting	area treated (acres)	800	$450	$360,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	200	$1,600	$320,000
	Land Protected, Acquired, or Leased - Streambank Protected	miles	12	$80,000	$960,000
	Nutrient Enrichment - Carcass Analog	area treated (acres)	50	$4,000	$200,000
	Project maintenance - Site Maintenance	miles	6	$4,000	$24,000
					$8,049,340
Upper Little Klickitat MaSA	Fish Passage - Culvert Replacement	# of installations	1	$125,000	$125,000
	Instream - Channel Connectivity	length treated in miles	0.5	$475,200	$237,600
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	22	$475,200	$10,454,400
	Instream - Spawning Gravel Placement	length treated in miles	11	$90,000	$990,000
	Instream - Large Woody Debris	# of structures	55	$1,000	$55,000
	Instream - Structure/ Log Jam	# of structures	35	$9,000	$315,000
	Instream - Beaver Introduction	# of beavers introduced	15	$350	$5,250
	Riparian - Livestock Water Development	# of installations	40	$3,200	$128,000
	Riparian - Water Gap Development	# of installations	40	$1,200	$48,000
	Riparian - Fencing	miles	36	$10,000	$360,000
	Riparian - Planting	species; area treated (acres)	800	$2,000	$1,600,000
	Riparian - Weed Control	species; area treated (acres)	400	$1,600	$640,000
	Sediment Reduction - Road Reconstruction	miles	0.5	$3,000,000	$1,500,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	10	$1,800	$18,000
	Sediment Reduction - Road Drainage System Improvements	miles	30	$11,000	$330,000

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost	
	Sediment Reduction - Erosion Control Structures	# of erosion structures	20	$1,400	$28,000	
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	40	$1,600	$64,000	
	Upland- Vegetation - Planting	area treated (acres)	12800	$450	$5,760,000	
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	300	$800	$240,000	
	Land Protected, Acquired, or Leased - Streambank Protected	miles	22	$80,000	$1,760,000	
	Nutrient Enrichment - Carcass Analog	area treated (acres)	5	$4,000	$20,000	
	Project maintenance - Site Maintenance	miles	38	$4,000	$152,000	
					$24,830,250	
Upper Middle Klickitat MiSA	Instream - Structure/ Log Jam	# of structures	30	$28,000	$840,000	
	Riparian - Planting	species; area treated (acres)	40	$5,000	$200,000	
	Sediment Reduction - Road Reconstruction	miles	2	$26,000	$52,000	
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	6	$1,800	$10,800	
	Sediment Reduction - Road Drainage System Improvements	miles	16	$3,600	$57,600	
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	115	$1,600	$184,000	
	Project maintenance - Site Maintenance	miles	18	$1,500	$27,000	
				$1,371,400		Assumes River Route remains in place with only drainage improvements; estimates do not include roads falling under Forest & Fish jurisdiction
Trout Creek MiSA	Fish Passage - Culvert Replacement	# of installations	3	$250,000	$750,000	
	Instream - Channel reconfiguration (includes channel roughening)	length treated in miles	10	$475,200	$4,752,000	
	Instream - Spawning Gravel Placement	length treated in miles	10	$90,000	$900,000	
	Instream - Large Woody Debris	# of structures	15	$1,200	$18,000	
	Instream - Structure/ Log Jam	# of structures	30	$9,000	$270,000	

MaSA	Type/Subtype[a]	Unit[a]	# Units	Cost / Unit	Cost
	Instream - Beaver Introduction	# of beavers introduced	10	$350	$3,500
	Riparian - Planting	species; area treated (acres)	60	$3,900	$234,000
	Sediment Reduction - Road Reconstruction	miles	18	$26,000	$468,000
	Sediment Reduction - Road Stream Crossing Improvements (=Rocked Ford)	miles	5	$1,800	$9,000
	Sediment Reduction - Road Drainage System Improvements	miles	25	$3,800	$95,000
	Sediment Reduction - Erosion Control Structures	# of erosion structures	25	$1,400	$35,000
	Sediment Reduction - Sediment Traps and Upland Erosion Control (sediment control basins, windbreaks, planting, conservation land management)	# of erosion structures	15	$600	$9,000
	Upland- Vegetation - Invasive Plant Control	area treated (acres)	40	$1,600	$64,000
	Project maintenance - Site Maintenance	miles	10	$4,000	$40,000
					$7,647,500
West Fork Klickitat MaSA	Sediment Reduction - Road Reconstruction	miles	0.5	$1,200,000	$600,000
	Sediment Reduction - Road Drainage System Improvements	miles	15	$5,200	$78,000
	Project maintenance - Site Maintenance	miles	0.5	$12,000	$6,000
					$684,000

[a] from Table 1 in Plummer guidance document

8. Monitoring, Research, and Adaptive Management

This chapter summarizes current monitoring and research efforts in the Klickitat subbasin and also lists additional RM&E needs. Part of the recovery strategy for this subbasin is the collaborative development of a monitoring plan to address the additional information needs that statkeholders and scientists have identified.

Comprehensive, empirical monitoring data on fish populations and habitat are needed to identify appropriate projects and locations, populate habitat/production capacity modeling efforts (such as EDT, AHA, or other appropriate models), and inform adaptive management for the salmonid recovery plan. Information on fish distribution, abundance, productivity, habitat conditions, genetic diversity, pathogen levels, and other population parameters, as well as on population limiting factors, is necessary to help direct and evaluate these efforts. A coordinated monitoring program is needed to ensure that these various needs, including salmonid recovery planning, are met.

As part of implementing the Klickitat steelhead recovery plan, a detailed monitoring and evaluation program will be designed and incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS' guidance document, *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance* (NMFS 2007*)* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf.

8.1 Adaptive Management

Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. It is a process of adjusting management actions and/or directions based on new information. It means taking an experimental approach to a complex task, making one's assumptions clear, and continuously evaluating them in light of new information. It works best when the collection of performance data and methods of evaluation are designed to get the information managers need to make sound decisions.

As outlined in the NMFS *Adaptive Management* guidance document, several types of monitoring are needed to support adaptive management: (1) implementation and compliance monitoring, which is used to evaluate whether the recovery plan is being implemented; (2) status and trend monitoring, which assesses changes in the status of an ESU and its component populations, as well as changes in status or significance of the threats to the ESU; and (3) effectiveness monitoring, which tests hypotheses and determines (via research) whether an action is effective and should be continued. (These three types of monitoring are discussed in more detail below.) In addition, it is important to build in some research to illuminate the many unknowns in salmon recovery—the "critical uncertainties" that make management decisions all the harder. Critical uncertainty research may seem expensive or unnecessary in light of basic information needs; however, in the long run, it may reduce monitoring and implementation costs.

NMFS' guidance document presents a decision framework that can guide the design of a research, monitoring, and evaluation plan. The framework (Figure 8-1) contains two basic sorts of questions: (1) questions regarding ESU status (biological viability criteria) and (2) questions regarding statutory listing factors and factors limiting recovery (limiting factor and threats criteria). Evaluating a species for potential delisting requires an explicit analysis of both types of criteria.

The guidance document contains a more detailed discussion of the framework and identifies the specific questions that should be answered to evaluate ESU status. These specific questions take the form of a series of decision-question sets that address the status and change in status of a salmonid ESU and the risks posed by threats to the ESU. The decision-question sets are designed to elicit the information NMFS needs to make delisting decisions. For recovery planners, the framework can guide future decisions about strategies and actions aimed at achieving recovery goals.

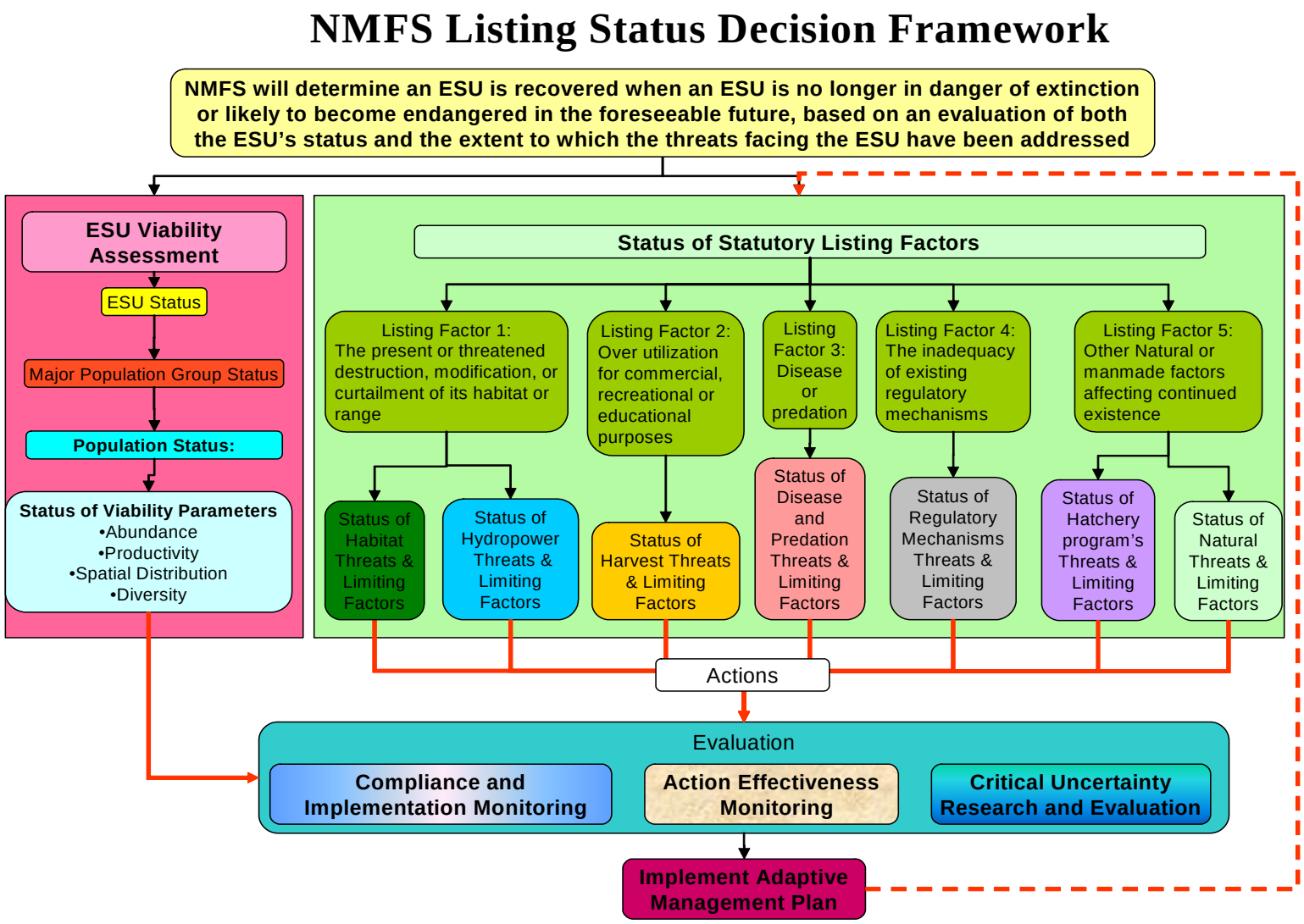


Figure 8-1 NMFS Listing Status Decision Framework.

8.2 Designing a Monitoring and Evaluation Program to Support Adaptive Management

Because of the length and complexity of the salmonid life cycle, there are many uncertainties involved in improving salmonid survival. Simply identifying cause-and-effect relationships between any given management action and characteristics of salmon populations can be a scientific challenge. It is essential to design a monitoring and evaluation program that will answer these basic questions: How will we know we are making progress? How will we get the information we need? And how will we use the information in decision making?

Designing an effective monitoring program for salmon recovery involves the following initial steps:

1. Clarify the questions that need to be answered for policy and management decision making. Include the full ESU and the full salmonid life cycle.
2. Identify entity or entities responsible for coordinating development of this program.
3. Identify:
    - Which populations and associated limiting factors to monitor
    - Metrics and indicators
    - Frequency, distribution, and intensity of monitoring
    - Tradeoffs and consequences of these choices
4. Assess the degree to which existing monitoring programs are consistent with NMFS guidance.
5. Identify needed adjustments in existing programs, additional monitoring needs, and strategy for filling those needs.
6. Develop a data management plan (See Appendix B of *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance (May 1, 2007)* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf.
7. Prioritize research needs for critical uncertainties, testing assumptions, etc.
8. Identify entities responsible for implementation.

A monitoring and evaluation program will provide (1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed, (2) a plan for tracking such metrics and indicators, and (3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the Plan's goals.

Implementation and compliance monitoring simply check on whether activities were carried out as planned, and whether specified criteria are being met as a direct result of an implemented action. For example, if a fence is planned for 20 miles of stream corridor to keep livestock off the stream banks so that riparian vegetation will rebound, implementation monitoring would verify the presence of the fence. Compliance monitoring would take note of the presence or absence of livestock in the fenced-off area.

Status and trend monitoring is a simple compilation of data-based descriptions of existing conditions. To be useful in decision-making, the raw data, or metrics, must be reduced to a

more directly applicable form or indicator. For example, if the question is "What is the annual spawning population size of steelhead in the X River?" the indicator would be total spawning numbers of steelhead over one season for the entire river basin; however, the metric, or directly measured thing, would be something quite different, perhaps steelhead redds sighted on weekly passes over known spawning grounds. Thus, the metric must be processed to translate it from the metric data type (e.g., redds) into the indicator data type (e.g., spawners), and then reduced to generate the indicator required (e.g., list of weekly counts on spawning grounds to annual total for watershed). The ICTRT identified deficiencies in the currently available data and/or data-gathering techniques for Middle Columbia River steelhead. These are described in Section 10.4, below.

Effectiveness monitoring specifically addresses cause-and-effect questions. Demonstrating the direct and indirect impact of management actions requires supporting all steps in the logical chain that connects the action to its expected impact. This chain is rarely short and usually contains several hypotheses. For this reason, it's better to build the effectiveness monitoring into the recovery action strategies, with, for example, pilot-scale tests or other methods carefully thought out beforehand. Monitoring and evaluation will only provide the answers to the questions they were designed to address; they do not provide the framework for revising these questions if they are ill-posed, evaluating the assumptions upon which the strategy was built, or incorporating learning into future decisions on actions and strategies—this is the role of adaptive management.

8.3 Existing Monitoring and Research

The development of the Klickitat Recovery RM&E Plan should begin by evaluating existing monitoring and research programs to determine if they are sufficient to answer the questions identified in NMFS' *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance*. Research, monitoring and evaluation activities currently underway in the Klickitat Basin address the following categories:

Current/Recently Completed M&E Tasks	Purpose
1. Status and Trends Monitoring	Compilation or data-based description of existing conditions and long-term trends
2. Effectiveness Monitoring	Address cause and effect questions
3. Critical Uncertainty Research	Gather information to test critical assumptions or theories

There follows more specific information regarding current monitoring and research programs being conducted by the Yakama Nation, the WRIA 30 Watershed Planning Implementing Governments, and other parties. WRIA 30 Implementing Governments are state and local agencies tasked with implementing the WRIA 30 watershed management plan; the Governor has designated the Washington Department Ecology (Ecology) to represent state agencies (e.g., WDNR, WDFW, WDOH). These programs should be reviewed further when developing the final RM&E Plan for recovery, in the context of the NMFS' guidance.

8.3.1 Status and Trends Monitoring

- Temporal outmigration patterns and relative abundance for wild and hatchery salmon and steelhead populations are being monitored annually at 3 rotary screw trap locations (upper, middle, and lower mainstem Klickitat).
- Length frequency and age composition for wild salmon and steelhead populations are being monitored at 3 rotary screw trap locations.
- Temporal and spatial redd distribution for steelhead has been variably monitored throughout the subbasin since 1990.
- Global Positioning System (GPS) locations have been recorded for redds since 2003 by the Yakama Nation.
- Sport harvest is monitored by WDFW and tribal harvest is reported annually by the Yakama Nation.
- Habitat surveys have been conducted by State and private timberland owners using the Timber, Fish, and Wildlife (TFW) Ambient Monitoring Protocol since 1996. To date, approximately 80 sites on 40 streams have been surveyed by the Yakama Nation, including all major tributaries (many with multiple sites) and, multiple sites on the upper mainstem Klickitat. Some sites have been surveyed a second time; most sites are planned for resurvey on a 5 to 10-year basis.
- Klickitat County recently completed a study that provides baseline information regarding current shade levels throughout the Little Klickitat and Swale subbasins (Aspect and WPN 2009). This information will serve as baseline information to support long-term trend monitoring by Klickitat County Ecology, and the WRPAC.
- In cooperation with WDFW, an adult monitoring/trapping facility at Lyle Falls has been in operation since the summer of 2004.
- Gravel samples have been collected and analyzed annually from 12 sites distributed over the mainstem and major tributaries since 1999.
- Water temperature has been monitored continuously by the Yakama Nation since 1996 at 28 sites (36 sites since 2003) distributed throughout the subbasin.
- Basic water quality parameters have been monitored on a seasonal basis by the Yakama Nation since 2000 at most of these sites.
- Water quality (numerous parameters, including temperature) monitoring is conducted annually by the City of Goldendale, Central Klickitat Conservation District, and Ecology.
- Flow in the mainstem has been continuously monitored by the USGS for 82 years.
- Flow in the Little Klickitat is monitored by Ecology, the Central Klickitat Conservation District, the City of Goldendale, and Klickitat County. Flow was previously monitored in the Little Klickitat by the USGS, but was discontinued in 1968. The Yakama Nation is also monitoring flow at various sites.
- A SNOTEL snow monitoring station was established in the Simcoe Mountains in 2008 by NRCS and the WRIA 30 Implementing Governments http://www.or.nrcs.usda.gov/snow/maps/Washington_sitemap.html
- Groundwater quality is monitored by Ecology and the City of Goldendale. In addition, a study of groundwater quality was conducted in 2005 by Klickitat County.
- A well database is maintained by Ecology.
- Groundwater levels have been monitored in Swale Creek since 2001 by the City of Goldendale and Klickitat County (Germiat and Flynn 2007).

- The status and trends of fish habitat on state and private forest lands are being monitored under the State of Washington's Forest and Fish Agreement.
- In 2002-2004, approximately 1000 pathogen samples were collected from various sites throughout the subbasin; samples were analyzed by the U.S. Fish and Wildlife Service (USFWS) using protocols of the National Wild Fish Health Survey.

8.3.2 Effectiveness Monitoring

- Preliminary rotary screw trap efficiency estimates are being evaluated by the Yakama Nation.
- Preliminary adult trap efficiency at Lyle falls is being evaluated by the Yakama Nation.
- The effectiveness of the State Forest Practices rules are being evaluated under Washington State's Forest and Fish Agreement.
- Cameras to support video monitoring of passage at Lyle and Castile falls are being installed.

8.3.3 Critical Uncertainty Research

- Genetic sampling and analysis to date has yielded information regarding genetic divergence between hatchery and natural spawning summer steelhead and information on potential subpopulations of *O. mykiss* within the basin (Narum et al. 2006).
- Critical uncertainties regarding the effectiveness of the State Forest Practices rules are being researched under Washington State's Forest and Fish Agreement.
- A groundwater availability study was completed by Klickitat County in Swale Creek subbasin in 2007.
- Presence/absence surveys for juvenile and resident salmonids have been completed in the majority of subbasin tributaries and in the upper mainstem by the Yakama Nation.
- Abundance estimates have been completed in numerous tributaries by the Yakama Nation.
- An EDT reach analysis of spring Chinook was completed in the summer of 2000 and multiple EDT model iterations for steelhead were conducted in 2002-2005. EDT was utilized to run Proper Functioning Condition (PFC) within the Klickitat by the Yakama Nation.

8.4 Additional Needs

The following information is a list of preliminary monitoring and research needs that have been identified in the Klickitat subbasin. These preliminary needs may be further refined as the recovery plan RM&E Program evolves.

Five primary objectives of future RM&E have been identified:

A. *Monitor Klickitat subbasin fish population's viability attributes*
B. *Monitor Klickitat subbasin habitat conditions*
C. *Evaluate Klickitat subbasin in relation to habitat limiting factor status*
D. *Evaluate Klickitat subbasin hatchery actions in relation to limiting factor status*
E. *Answer key questions/uncertainties*

A. Monitor Klickitat subbasin fish population's viability attributes

Adult counts

- *Redd counts* (spawner surveys) - Regular foot and/or raft surveys will be conducted within the known geographic range for each species. Individual redds will be counted and their locations recorded using handheld GPS units. Counts of live fish of all salmonid species and carcasses will also be recorded. Carcasses will be examined for sex determination, egg/milt retention, and presence of CWT or PIT-tags or external experimental marks. Scale samples will also be taken from carcasses. Spawning ground surveys will be conducted for steelhead from late January through early June. Attempts will be made to cover the entire known spawning range. Stream reaches will be surveyed multiple times during the spawning periods, with most reaches receiving 3 passes.

- *Adult counts at Lyle Falls Fishway adult trap* – Trap is currently in operation with WDFW as partner. Salmonid species are counted as they are released from trap within the Lyle Falls Fishway on lower Klickitat. Trap efficiencies will be estimated from floy tagging of fish and recapture in sport fisheries or resighting during spawner/carcass surveys. Genetic and scale samples, along with fish length, will also be collected.

- *Adult counts at Castile Falls Fishway* – Adult trap, video monitoring, and PIT-tag detection equipment will be installed at Castile Falls Fishway (RM 64). Adult counts will be used for upper subbasin production estimates, fish-per-redd estimates, and Castile Fishway improvement effectiveness monitoring. Genetic and scale samples, along with fish length, may also be collected.

- Additional methods for adult enumeration should be investigated.

Juvenile production and survival estimation

- *Juvenile production estimation* – Floating rotary screw traps located just above Lyle Falls (RM 2.8) and at the Klickitat Hatchery (RM 43) will be operated on a year-round basis. A rotary trap located above Castile Falls (RM 64.6) will be fished seasonally from early summer through fall. Environmental and trap data (weather conditions, water temperature and clarity, trap revolution speed, and debris load) will be recorded along with bio-data (fork lengths, weights and smoltification stage), and additional fish will tallied by species. Trap efficiencies will be estimated regularly by mark/recapture trials using fin clips, fin markings, and/or PIT-tags. Feasibility of intermittent juvenile trapping on lower White Creek will also be investigated (in conjunction with an instream PIT-tag detector; juvenile production estimates may be possible).

- *Smolt-to-Adult Return estimation* – PIT-tagging of wild and hatchery smolts. Detection will be at instream detectors (White Creek), screw traps, and Bonneville Dam as smolts; at Bonneville Dam, adult traps, and on spawner surveys as adults.

Age structure and sex ratio sampling

- *Adult scale, sex, origin (i.e., HOF or NOF), and length sampling* – at adult traps and spawner surveys
- *Juvenile scale and length sampling* – at screw traps
- *Scale analysis* – Scale age will be determined by technicians trained in WDFW methodology.

Juvenile and resident fish monitoring

- *Presence/absence surveys* – Electrofishing and snorkel surveys will be used to determine presence/absence of fish species in selected tributaries.
- *Abundance estimates* – Multiple pass electrofishing sampling and snorkel surveys will be used to estimate abundance in selected stream reaches, including selected habitat enhancement sites.

B. Monitor Klickitat subbasin habitat conditions

Stream habitat monitoring

- *Stream habitat surveys* – Habitat surveys will be conducted on approximately 5-10 stream reaches per year using TFW methodology, Reference Point Survey, and Large Woody Debris Survey.
- *Spawning gravel/sediment sampling* – core samples will be collected from approximately 12 sites (in the Klickitat mainstem and major tributaries) per year.
- *Stream temperature and water quality monitoring* – Water temperature will be continuously monitored at approximately 36 sites throughout the subbasin using thermographs plus approximately 29 sites in the Little Klickitat and Swale Creek subbasins. Basic water quality parameter measurements (pH, conductivity, dissolved oxygen, turbidity) will be recorded seasonally (4-6 times per year) at approximately the same sites. Riparian vegetation and effective shade will be monitored (approximately every five years, depending on availability of new aerial photography) in the Little Klickitat Basin and Swale Creek.

C. Evaluate Klickitat subbasin in relation to habitat limiting factor status

Limiting factors identification and assessment of anthropogenic effects on limiting factors identified

- To date, not all the factors limiting steelhead production in the Klickitat basin have been quantitatively assessed. Limiting factors identification and assessment of possible anthropogenic effects need to continue in order to ensure that actions taken are adequately addressing the factors and threats.

Fish passage improvement effectiveness monitoring

- *Radio telemetry study* – This study will radio-tag and monitor movements of steelhead and spring Chinook salmon; passage at Lyle Falls, Castile Falls, Little Klickitat Falls, and other passage impediments will be evaluated.

- *Reach-scale spawner surveys (redd counts)* – Spawner surveys in reaches upstream of passage improvements will be conducted, as a part of the larger ongoing subbasin-wide spawner survey effort, to evaluate culvert replacement projects, and passage upstream of impediments (e.g., Castile Falls).

Instream habitat enhancement effectiveness monitoring

- *Subbasin-scale juvenile production estimation* – Screw trapping and resulting wild smolt production estimates will be used for comparison of before and after habitat actions. The general hypothesis to be tested is that wild smolt production will increase following habitat restoration/ enhancement actions (although multiple years of data will likely be necessary to detect any real trends in abundance over year-to-year variations). Additionally, in conjunction with redd counts and fecundity estimates (derived either from literature or proposed hatchery production in the Klickitat), the feasibility of generating valid and precise egg-to-smolt survival estimates (before and after habitat actions) will be investigated.

- *Tributary-scale juvenile production estimation* – The feasibility of juvenile trapping in lower White Creek for production/abundance estimation (in conjunction with instream PIT-tag detector) will be investigated.

- *Reach-scale abundance estimates* – Will conduct multiple-pass electrofishing removal sampling and snorkel surveys in selected reaches or localized sites that receive habitat actions. The general hypothesis to be tested is that instream habitat actions increase abundance of fish locally.

- *Reach, tributary, and subbasin scale habitat quality and quantity estimates* – The effectiveness of actions designed to improve instream habitat needs to be evaluated to determine if actions are effectively improving habitat. If not, actions should be modified based on the results of the monitoring and assessment to improve effectiveness.

Local technical review panel involvement

- *Klickitat Technical Committee* – a local technical review panel is part of the Washington Salmon Recovery Funding Board process for reviewing and funding habitat restoration/enhancement projects.

EDT modeling and/or other appropriate models (e.g., Habitat Assessment Model)

- *Incorporate new habitat data* – Data from ongoing habitat surveys will be incorporated for future model runs.

- *Incorporate new biological data* – Data from adult trap facilities, genetic analysis, scale age analysis, and harvest estimates will be incorporated for future model runs.
- *Perform model runs* – To assist in identifying sites and/or potential benefits of future habitat restoration/enhancement projects.
- *Validate Model***.**

D. Evaluate Klickitat subbasin hatchery actions in relation to limiting factor status

Smolt-to-adult return estimation

- *PIT-tagging of hatchery and wild smolts* – detection at screw traps and Bonneville Dam and comparison of wild to hatchery survival rates. In general, the hypothesis to be tested is that smolt-to-adult return rates of hatchery steelhead adults are not significantly different than wild steelhead adults. Differences between hatchery rearing strategies will also be tested. Tagging numbers for steelhead are as follows:

    - 10,000 hatchery steelhead smolts (from native broodstock for rearing study)
    - 10,000 Skamania Hatchery steelhead smolts (feasibility and contract development will be coordinated with WDFW)
    - Approx. 2000 wild steelhead smolts (see also additional PIT-tagging on White Creek)

Adult spawner monitoring

- *Spawner surveys* – sampling of steelhead, coho, and fall Chinook salmon carcasses on spawning grounds and estimation of wild/hatchery ratios.

Demographic characteristic comparisons

- *Age structure, sex ratio, and length-at-age* – Using scale, sex, and length sampling that occur at adult traps and on spawner surveys, comparisons of these demographic characteristics will be made between hatchery and wild returning adults. The hypothesis to be tested is that hatchery adults are not significantly different than wild adults in these characteristics.

Genetic sampling and analysis

- *Genetic sampling* –To gain a thorough understanding of the genetic make-up of target stocks in order to maintain long-term genetic variability (within- and between-population) and minimize the impacts of domestication on supplemented stocks (spring Chinook salmon and summer steelhead), samples will be collected at adult traps, screw traps, and via electrofishing.

- *Genetic analysis* – DNA analysis will be carried out by CRITFC geneticists under subcontract. Results will help assess the level of domestication and

interbreeding between hatchery and wild stocks pre- and post-supplementation. As identified in the draft Klickitat subbasin Anadromous Fishery Master Plan, summer steelhead will be collected for broodstock at Lyle Falls. A thorough knowledge of baseline genetic conditions and dip-in rates by out-of-subbasin adults is important in order to adhere to the YKFP genetic guidelines.

Fish health sampling and analysis

- *Pathogen sampling* – A baseline data set will be augmented by describing existing levels of pathogens in wild resident trout and naturally produced steelhead in order to determine if supplementation increases the incidence of pathogens. YN field crews will collect samples within the range of anadromy within the Klickitat subbasin. Samples will be examined for pathogens by the USFWS Lower Columbia River Fish Health Center.

Hatchery releases of introduced Species

- Identify the abundance of naturally spawning coho and fall Chinook utilizing the spawner surveys, redd counts, and trap data. Ensure that spawner surveys for coho and Chinook are extended to cover the full distribution of known steelhead spawning.
- Develop estimates of abundance and productivity of naturally spawning coho and fall Chinook.
- Evaluate the overlap in habitats utilized by steelhead, coho, and fall Chinook for spawning and rearing.
- Evaluate the effects of competition between steelhead, coho, and fall Chinook.
- Estimate the amount of steelhead habitat displaced by hatchery released and naturally spawning coho and fall Chinook.
- Estimate the effects of coho and fall Chinook on steelhead viability.

EDT and AHA modeling and/or other appropriate models (e.g., Habitat Assessment Model)

- *Incorporate new habitat data* – Data from ongoing habitat surveys will be incorporated for future model runs.
- *Incorporate new biological data* – Data from adult trap facilities, genetic analysis, scale age analysis, and harvest estimates will be incorporated for future model runs.
- *Perform model runs* – To guide supplementation efforts.
- *Validate the models***.**

E. Answer key questions/uncertainties

Determine migration behavior, passage delays, habitat use, and life history characteristics of steelhead and spring Chinook salmon

- *Radio telemetry study* – Using radio telemetry techniques, the travel times, passage delays, tributary usage, and spawning and holding locations of steelhead and spring Chinook salmon will be described. Differences in these traits between wild and hatchery steelhead, and summer and winter steelhead,

will be determined and will provide a baseline to assess any changes that occur following proposed supplementation, and to provide proportional use information for abundance estimates that result from redd counts. Effectiveness of passage improvements at certain sites can also be evaluated. Specific questions that can be addressed include:

1) Tributary use vs. mainstem use.

2) Spawning areas, holding phase locations.

3) Migration behavior/migration phase travel times/spawning site search phase distances traveled.

4) Frequency and consequences of fallback at Lyle Falls.

5) Amount of delay at Klickitat Hatchery weir.

6) Amount of delay/passage at Castile Falls.

7) Post-spawn kelt survival, movement, and emigration.

Methods that will be used are as follows: Fish will be captured at Lyle Falls adult trap and implanted with radio tags and PIT-tags; fixed telemetry receiver sites will be installed at various locations in the Klickitat subbasin (potential passage impediments and major tributary confluences) to detect fish locations; mobile tracking (via foot, raft, or automobile) will be employed on a weekly or biweekly basis, fish locations will be recorded using GPS receivers, and PIT-tags will allow for fish identification after the radio-tag battery expires, Bonneville Dam detection, and returning kelt detection. Approximate number of steelhead tagged per year would be as follows:

- 2007 – 50 wild steelhead, 50 hatchery steelhead
- 2009 – 50 wild steelhead, 50 hatchery steelhead

This project will be conducted as a cooperative project between YN/YKFP and USGS Columbia River Research Laboratory. USGS staff would perform radio tag implanting and radio tracking (with assistance from YN staff), as well as most data management and analysis, under a subcontract with YN. USGS staff would provide and install fixed telemetry receiver site equipment as an in kind contribution.

Determine migration and rearing patterns in White Creek watershed

- *Install instream PIT-tag detector on lower White Creek* – An instream PIT-tag detector would be installed on lower White Creek to detect outmigrating juveniles and determine outmigration timing and relative abundance. The White Creek watershed has been the most heavily used Klickitat tributary watershed by adult steelhead in recent years, yet many reaches go dry due to

lack of base flows and pool habitat. Determining migration and rearing patterns will help assess importance of White Creek vs. mainstem Klickitat rearing habitat and help evaluate habitat improvement actions. USGS Columbia River Research Laboratory staff would install PIT-tag detector and assist with data management (under subcontract with YN). PIT-tagging would be conducted by YN staff, with approximately 1500 fish tagged per year via electrofishing in the White Creek watershed.

Evaluate Little Klickitat passage frequency

- *Reach-scale spawner surveys (redd counts)* – Additional reaches in the upper Little Klickitat River watershed will be targeted for spawner surveys in an ongoing attempt to describe passage frequency of adult steelhead over Little Klickitat Falls (RM 6). Adult steelhead have been observed above the falls during high flow years, but passage frequency is unknown. This information will assist in EDT modeling purposes, and for evaluation of potential future habitat projects.

Steelhead rearing study

- *Assessment of survival and residualism in hatchery-raised steelhead using differential growth regimes* – Abundance of wild indigenous summer steelhead within the Klickitat subbasin has been depressed for a number of decades. Continued releases of a domesticated, non-endemic (Skamania) stock poses unacceptable risks to the native Klickitat summer steelhead population. Future management actions are proposing to phase out Skamania-origin releases in favor of developing a new, integrated hatchery program using Klickitat indigenous steelhead as a broodstock source. Goals for the long-term development of the program include:

- Conserve and restore indigenous stock to historical distribution and abundance levels
- Minimize residualism rates
- Maximize survival and adult return rates
- Mimic natural growth patterns and size of wild counterparts
- Improve tribal and sport fishing opportunities

Table 8-1 Summary of ongoing and expanded RM&E cost estimates (Sharp et al. 2008, Klickitat County, personal communication 2009).

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY2017
YN RM&E Ongoing	$520,000	$533,000	$546,325	$559,983	$573,983	$588,332	$603,041	$618,117	$633,570	$649,409
WRIA 30 RM&E Ongoing	$111,200	$131,500	$41,000	$81,000	$41,000	$41,000	$41,000	$41,000	$81,000	$41,000
On-going RM&E Subtotal	**$631,200**	**$664,500**	**$587,325**	**$640,983**	**$614,983**	**$629,332**	**$644,041**	**$659,117**	**$714,570**	**$690,409**
YN RM&E Expanded	$365,642	$374,783	$857,452	$878,888	$900,861	$923,382	$946,467	$970,128	$994,381	$1,019,241
WRIA 30 RM&E Expanded	$ -	$85,000	$918,500	$909,000	$1,142,000	$890,000	$945,000	$10,000	$10,000	$10,000
RM&E Expanded Subtotal	**$365,642**	**$459,783**	**$1,775,952**	**$1,787,888**	**$2,042,861**	**$1,813,382**	**$1,891,467**	**$980,128**	**$1,004,381**	**$1,029,241**
Total	**$996,842**	**$1,124,283**	**$2,363,277**	**$2,428,871**	**$2,657,844**	**$2,442,714**	**$2,535,508**	**$1,639,245**	**$1,718,951**	**$1,719,650**

YN Staff cost estimates assume a 2.5% inflation rate (starting with FY 2008 dollars)
Klickitat County cost estimates do not apply an inflation rate

8.5 Data Management

A formal and documented approach to data management is essential to adaptive management. A well-designed data management plan can help to ensure that data of a specified quality and quantity is available, at a specified time, to meet specified data analysis needs.

Protocols, metrics, and other data standardization tools such as common data entry methods are a top priority for recovery plans. Coordination across existing monitoring programs and projects will be underpinned by an integrated monitoring and data management framework. The framework would, for example, require the use of common methodologies for sample design, data collection, data validation, and data sharing in order to address common questions. Data management systems should be developed and coordinated with national and regional efforts for consistency with regional and national data standards. Project implementation data management

should be consistent with PCSRF protocols where appropriate and with guidance from PNAMP's effectiveness work group. Further guidance on data management is provided in the NMFS guidance document, *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance*.

8.6 Consistency with Other Monitoring Programs

This recovery plan will utilize existing monitoring programs to evaluate the status/trend and effectiveness of recovery actions within the Klickitat Basin. Specifically, this approach should incorporate strategies, indicators, and protocols described in the Yakima Klickitat Fisheries Project, the WRIA 30 Watershed Management Plan, the Upper Columbia Monitoring Strategy, the Comprehensive Statewide Monitoring Strategy, and Collaborative Systemwide Monitoring and Evaluation Project (CSMEP). The development of other regional monitoring programs may result in modifications to the monitoring programs used in the Klickitat Basin. These other programs, in various states of development, include such approaches as Pacific Northwest Aquatic Monitoring Partnership (PNAMP). As these programs develop more fully, they will provide guidance on valid sampling and statistical designs, measuring protocols, and data management. This information may be used to refine and improve the existing monitoring and evaluation programs in the Klickitat Basin. The intent is to make monitoring and evaluation programs in the Klickitat Basin consistent with programs throughout the ESUs and Columbia Basin.

8.7 Coordination

Many entities have been or will be implementing recovery actions within and downstream from the Klickitat Basin. Monitoring programs to coordinate with include:

- Yakima Klickitat Fisheries Project,
- NOAA Fisheries RME Program,
- Washington Salmon Recovery Funding Board Program,
- PACFISH/INFISH Monitoring Program,
- Pacific Northwest Interagency Regional Monitoring Program,
- USFWS, USGS, and BOR Monitoring Programs,
- WDFW and WDOE Monitoring Programs,
- Local Underwood Conservation District Monitoring, and
- WRIA 30 Implementing Governments.

It is critical that these programs be consulted to emphasize utility, reduce redundancy, increase efficiency, and minimize costs.

8.8 Evaluation Schedule

Tracking progress or needs for adaptive management in the Klickitat subbasin by evaluating information from the recovery plan's research and monitoring programs could be one of the roles of the Washington Gorge Area Regional Board. Appropriate time intervals and triggers/goals need to be established to evaluate project implementation, compliance and effectiveness, the status and change in status of a population's viability attributes, the status of population's limiting factors and the evaluation of research identified in the recovery plan.

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Appendix I. Major Creek

Major Creek, a small tributary to the Columbia River, lies just downstream of the Klickitat River drainage (Figure I-1). Major Creek is believed to support Middle Columbia steelhead. This appendix provides an overview of the Major Creek watershed and current knowledge concerning steelhead use. Section 5 proposes further research.

1 Physical Setting

Major Creek drains directly into the Columbia River adjacent to the Klickitat subbasin. The Major Creek watershed covers about 28 sq. miles or 7,200 acres of land. Two forks of Major Creek, East and West Fork, converge, flowing 4.1 miles downstream to the Columbia River, dropping 620 feet in elevation. The West Fork originates at two catch basins at 2,100 feet, flowing 5 miles through a narrow box canyon, then through a valley to the confluence with the East Fork, losing 1,360 feet in elevation. The East Fork flows from a drainage basin 5.1 miles through a narrow, v-shaped valley, losing 1,490 feet in elevation, to join the West Fork.

The Major Creek watershed is under a mix of ownership, including U.S. Forest Service, BIA trust lands, Washington Department of Natural Resources, and private landowners. Most of the Major Creek drainage lies within the Columbia Gorge National Scenic Area and is managed by the USFS. It is one of the few riparian corridors connecting the Columbia River and the highlands (USFS 2005). Other riparian corridors in the area connecting the Columbia River to the highlands include the White Salmon, the Klickitat, and Rock Creek.

2 Ecosystem Conditions

The main channel of Major Creek in the anadromous reaches averaged 7 percent gradient to 8 percent at the confluence of the East and West forks. The average gradient in the fish-bearing reaches of the West Fork was measured at 8 percent, while the lower section of the East Fork had an average gradient of 15 percent. There is a 30-foot waterfall at RM 1.37 on the West Fork and another waterfall at RM 1.2 on the East Fork that likely limit upstream *O. mykiss* distribution, though precise extent of distribution remains to be determined.

Major Creek has a relatively straight, high energy, swiftly dropping channel incised into the Columbia River basalt layers. Streamside vegetation is relatively dense, and the rate of downcutting generally does not seem to be outstripping the rate at which the riparian vegetation can stabilize the stream banks. Water quality appears to be high. The Major Creek landscape is canyon-dominated with very little road contact, and except for the uppermost portion of the watershed, the watershed is very lightly managed. The vegetation is dominated by grasslands and oak woodlands in the lower sections, while the higher elevations are more forested, with Douglas and grand fir, and some intermittent

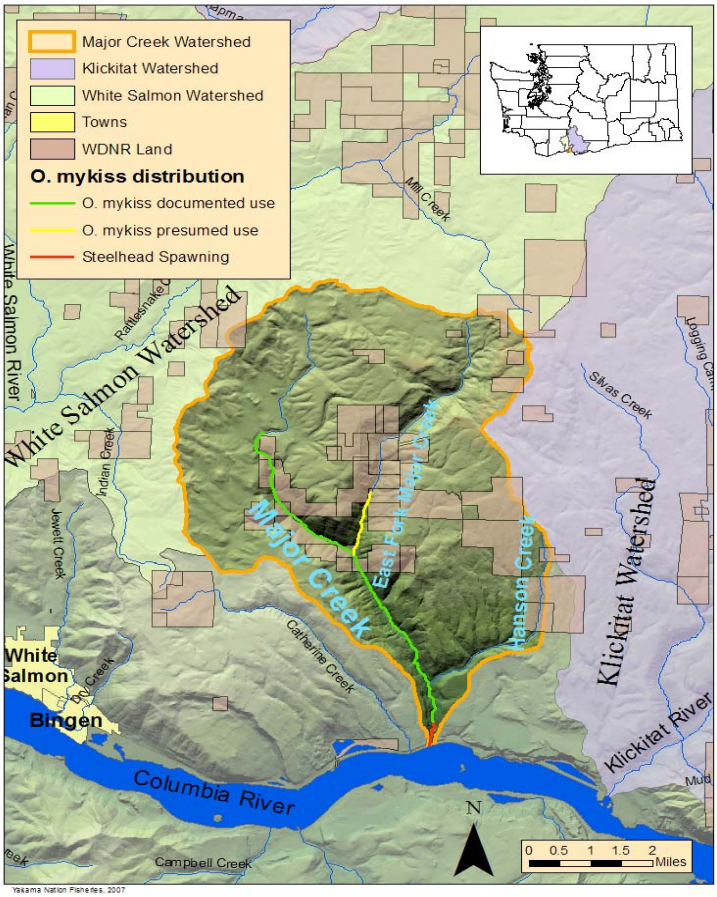


Figure I-1. Map of the Major Creek Subbasin in Southern Washington showing steelhead distribution. (YN Fisheries, personal communication 2007).

oak woodlands and hay lands. The riparian areas along the lower stretches of Major Creek have a good diversity of oak, ash, alder, willow and big leaf maple. Despite impact from human activities, most of the ecological functions are intact (USFS 1994).

Major Creek has a "flashy" hydrograph, especially during rain-on-snow events. Surface flow is at least 1 cfs throughout the driest portions of the summer in all but the first one-quarter mile. Low flow to sub-surface flow conditions exist in the bottom one-quarter mile above the confluence to the Columbia, mainly due to percolation through alluvial material in this reach.

Water temperatures in Major Creek exceed water quality standards during the summer; however, several springs and numerous large pools help provide cooler rearing habitat. Water temperatures in Major Creek range from 0.5ºC in the winter to 21.5°C during the summer in the upper watershed and from 0.1°C in the winter to 24°C during the summer in the lower watershed. Dissolved oxygen (DO) and pH in Major Creek are good year-round.

Habitat conditions in the Major Creek watershed display impacts from past and present land use activities. The largest human impacts on the Major Creek watershed are from SR 14, the railroad along the Columbia River, and, in the higher reaches, road and logging impacts. In the headwater sections of the West Fork of Major Creek, land clearing for farming and residential development has caused habitat fragmentation and loss of wetland functionality. The East Fork is still largely owned by commercial timber interests. Clearing, subdivision and development have not occurred with similar intensity; however, widespread habitat fragmentation has occurred as the result of timber harvest. Years of fire suppression, draining and ditching of wet meadows, and other land uses have changed the composition of the vegetation, resulting in an absence of large woody debris, a vital component of structure for fish habitat in the stream. It is also unclear what effect a seven-mile-long log flume, in operation in the early 1900s in Major Creek, had on the channel conditions and blockage at the barrier falls (USFS 2005).

The area of the watershed within the Columbia Gorge National Scenic Area (NSA) has been influenced more heavily by grazing and forest practices than by residential and agricultural uses. Wetlands have been drained and overgrazed, meadow areas converted to agricultural land, and large areas of forest cleared. Sedimentation, likely due in part at least to roads and timber harvest, has increased over historical conditions, while forest and agricultural practices, including the application of fertilizers and herbicides, have had a heavy impact on water quality (USFS 2005). Logging is likely to continue to the north and east of Major Creek. Grazing still occurs in private, BIA trust, and privately owned timber lands. Concomitant impacts of grazing — bank erosion, sedimentation, loss of fish habitat, and reduction in other aquatic life — are being documented with increasing frequency (USFS 2005).

3 Current Status

The ICTRT groups small downstream mainstem tributaries with the closest upstream population drainage, in this case the Klickitat River (ICTRT 2003). Thus, steelhead in Major Creek are considered part of the Klickitat population of Middle Columbia River steelhead.

The ICTRT has identified intrinsic habitat within Major Creek, but has not yet assessed the population because of lack of data. A barrier identified as a complete block at RM 0.32 in earlier subbasin reports and Salmonscape limited previous assessments of habitat in this watershed to the very lowest reaches. More recent information provided by the Yakama Nation and described in this section suggests that steelhead were able to maneuver this barrier under some flow conditions. If so, the ICTRT may conclude after further evaluation that the additional upstream habitat contains enough intrinsic spawning branch area to form an additional MiSA within the Klickitat population.

Steelhead, as well as fall Chinook salmon and coho salmon, spawning activity has been documented in the lower one-third mile of Major Creek (YN Fisheries, personal communication 2007; USFS 1994). Adult steelhead, some with adipose fins, have been observed in this same section in spring (R. Gerstenberger, written communication 2006) staging below each of the lower falls (E. Jones, personal communication 2006) and attempting

to jump the triple step falls (R. Gerstenberger, written communication 2006). *O. mykiss* have been observed up to a natural fish barrier at RM 1.4 on the West Fork and to the natural barrier at RM 1.2 on the East Fork (USFS 1994). *O. mykiss* spawning has been observed up to the Old Hwy. 8 culvert/crossing, and fry have been observed as far as 0.5 to 1 mi. above the Acme Rd. crossing on the West Fork. Two steelhead redds were observed in the lower 0.25 miles of the creek in March 2007 (G. Morris, YN, unpublished data, 2007).

Above the first one-third mile, Major Creek is limited primarily to *O. mykiss* due to a triple step falls with a total drop of approximately 20 feet (G. Morris, YN unpublished data, 2007); each step appears to be less than 6 feet (R. Gerstenberger, written communication 2006). This barrier was originally used as a complete block in the ICTRT's intrinsic potential analysis. Winter and spring flows are sufficient to enable some steelhead to negotiate the obstacle, and steelhead have been seen above the falls, though passage frequency is unknown (YN, unpublished data). A steelhead carcass was observed in a pool above the step falls in May 2006 (R. Gerstenberger, written communication 2006).

Further field studies need to be conducted in the middle reaches to characterize the habitat and potential barriers, as well as to ascertain the uppermost limit of use of Major Creek by steelhead.

4 Potential Limiting Factors and Threats

This section summarizes potential limiting factors and threats for steelhead in Major Creek.

Apparent factors limiting steelhead productivity in the Major Creek system include lack of adequate spawning gravel in all but the lower 0.32 miles, a lack of large woody debris (except for a few large debris jams), and a low pool-to-riffle ratio. The triple falls on the main branch of the creek at RM 0.32 form at least a partial fish barrier, as do several falls higher up on the East and West forks (at RM 1.2 and 1.4, respectively). Water volume and temperature are possibly also issues, particularly in those reaches where the flow diminishes during the summer months. Although the canopy of riparian vegetation is intact in much of the watershed, there are areas where the vegetation is thin. An open canopy exists in the lowest, anadromous reach (RM 0.0-.32), with an estimated 19 percent shade cover, while in upper reaches shade ranges from approximately 20 percent (adjacent to private pasture land) to 60 percent in more densely wooded and/or steep canyon sections (USFS 1994). There is also a relative overall scarcity of large trees for future recruitment to provide stream structure and cover for adult fish. Lack of LWD, stream bank instability and siltation may also affect habitat in the East Fork (USFS 1994). A fairly extensive stream survey was conducted in 1994, and spawning surveys are conducted sporadically; however, an extensive survey is needed to determine the extent of anadromous fish use, and the extent of habitat change that may have occurred as the result of the 1996 flood and other floods (scouring, bank erosion, debris jams), effects of upland land use, roads, etc.

5 Management Actions

The Yakama Nation has proposed several actions to address limiting factors and threats for steelhead production in Major Creek. The actions propose biological, physical, and watershed

assessments to gain needed baseline information to determine future restoration and protection needs in the Major Creek watershed (Table I-1).

Table I-1. Needed Actions, Estimated Time to Implement, and Cost for Assessment of Wild Major Creek Steelhead Provided by Yakama Nation Fisheries Staff.

Actions	Affected Sites	Time to Imple ment	Time to Real-ize Bene-fits	Imple-menting Entities	Esti-mated Cost	Imple-ment-ability (L-M-H)	Comment
Physical habitat assessment: assess flow and temperature regime, riparian cover, substrate, map and quantify stream habitat	Mainstem Major Creek, East Fork, West Fork	< 3 Years	5 - 10 Years	Yakama Nation, USFS, USGS	$0 -- 100,000	High-	Determine location and volume of any spring inputs
Biological assessment: assess use of watershed by steelhead; frequency of steelhead passage at lower falls; fish species composition, health, and life history; genetics and spawning distribution.	Entire watershed: below and above the falls (RM 0.3) into all of accessible upper watershed.	< 3 Years	5 - 10 Years	Yakama Nation, USFS, USGS	$0 -- 100,000	High	Actions will provide baseline information on Major Creek fish populations: distribution, productivity, life history, relationship between upper and lower watershed *O. mykiss* and relationship to ESU/MPG.
Watershed assessment: assess roads, passage structures, land use, water withdrawals and identify potential restoration sites.	Entire watershed.	< 3 Years	5 - 10 Years	Yakama Nation, USFS, USGS, private landowners	$0 -- 100,000	High	Investigate water withdrawal location and amounts, including legal maximum water rights.
Investigate feasibility of placing/place margin structures.	Entire watershed	3 - 5 Years	3 - 5 Years	Yakama Nation, USFS, USGS, private landowners	$500,000 – 1,000,000	Moderate	Margin structures would retain some spawning gravel patches, would create holding habitat (slow water pockets) and provide cover for adult fish heading upstream, as well as for juveniles moving downstream.

6 Cost Estimates

The Yakama Nation Fisheries staff provided estimated habitat action costs for research/evaluation and channel/floodplain modification for Major Creek. Costs over a 10-year period are estimated to be $0.45 million ($0.15 million for years 1-3 and $0.3million for years 4 to 10).

Appendix II. Potential Limiting Factors and Threats Identified by Yakama Nation Fisheries

This appendix describes the potential limiting factors and threats identified by Yakama Nation Fisheries staff for Middle Columbia River steelhead in the Klickitat subbasin. Limiting factors are described qualitatively in relation to the biological needs of the species and threats are described as those activities (natural or anthropogenic actions) that lead to the limiting factors.

Yakama Nation Fisheries biologists consider the following conditions to be the top habitat factors (physical and biological) limiting the viability of the threatened Klickitat *O. mykiss* population. The Yakama Nation staff identified the factors based on 10 years of fisheries and physical habitat data, EDT model outputs, and the professional opinion of biologists and other scientists working in the watershed.

- ***Degraded riparian condition.*** Riparian corridors have been affected and eroded by past, and in some cases current, timber practices, poor road construction and management, inadequately sized stream crossings, off-season use of wet roads, and cattle grazing in riparian areas. McCormick Meadows, in the tribally designated Primitive Area on the upper Klickitat River, was heavily grazed for approximately 60 years. Compromised riparian conditions reduce channel stability and pool frequency, and thus key habitat quantity and habitat diversity, degrading juvenile rearing habitat. Reduced riparian cover also affects fish survival and productivity by reducing stream shade, which leads to an increase in maximum water temperatures, and by limiting recruitment of large woody debris needed to provide future instream habitat complexity. Channel instability contributes significantly to increased sediment loads. Creation of Bonneville Pool inundated the lower reaches of the subbasin and resulted in the loss of critical wetland riparian habitat.

- ***Decreased floodplain function and channel migration processes.*** Abandoned and active roads, highways and a railroad prism in the floodplain along the lower Klickitat mainstem and lower Swale Creek, and active logging roads in the upper watershed confine and harden banks causing channelization, incision of tributaries, disconnection of side-channels and river meanders, and other disruption of natural hydrologic and riparian processes.

- ***Altered hydrology.*** Increased peak flows and diminished base flows in several parts of the subbasin have degraded habitat for fish. White Creek, Swale Creek, the Little Klickitat River and many of its tributaries have been identified as having insufficient instream flows to support fish populations (anadromous and resident). Swale Creek and six reaches on the Little Klickitat, Blockhouse, Bloodgood, Bowman and Mill creeks were considered “water quality impaired” on the 1998 state 303(d) list for instream flows.

- ***Degraded channel structure and complexity.*** In-channel large woody debris in the watershed has declined as a result of reduced recruitment potential (from bank hardening and historical riparian logging), historical "stream cleaning," and altered hydraulic conditions associated with increases in peak runoff and channel simplification. This reduction of in-channel structure and its concomitant effects has deprived fish of needed hiding, resting and rearing habitat.

- ***Obstructions to fish passage and connectivity.*** A number of culverts in the subbasin block fish passage. Reduced low flows have led to loss of connectivity of habitats in some streams, effectively cutting off migratory paths and isolating fish. High temperatures during low flow periods effectively act as barriers preventing fish from moving between spawning, rearing and migration habitats. Historical torrents associated with road crossing failures may have exacerbated passage difficulties in localized areas (e.g. lower Trout Creek).

- ***Altered sediment routing.*** Sediment loads (the percentage of fines in spawning gravel, embeddedness and turbidity) in the Klickitat have increased over historical conditions. Actions contributing to increased sediment delivery include forest practices (skidding and road building, clearing of upland forests and stream banks), agricultural practices (rill irrigation, streamside grazing) and land clearing and excavation in or near riparian areas related to residential and commercial construction. Increased sediment loads are a key problem for steelhead, particularly during the egg incubation stage. In addition, runoff from Mt. Adams' glaciers, carried downstream by such streams as Big Muddy Creek, is a significant source of natural sediment in the Klickitat River.

- ***Degraded water quality, including water temperatures.*** While most of the mainstem Klickitat and most tributaries maintain fairly healthy temperatures for anadromous fish, elevated summer and in certain reaches extremely low winter stream temperatures restrict steelhead production in several areas. Reaches on the East Prong, West Prong and mainstem Little Klickitat River, Butler Creek (a major tributary to the Little Klickitat) and Swale Creek were listed on WDOE's 1998 303(d) list for temperature (Anderson 2004; Brock and Stohr 2002). Nine reaches on these streams violated thermal water quality criteria. Degraded channel and riparian conditions, reduced summer low flows and lack of shading are presumed to exacerbate the elevated temperatures, though temperatures in some water bodies may naturally exceed state water quality criteria. Reduced flows, lack of pools and inadequate riparian cover also contribute to unfavorably low temperatures and the formation of anchor ice in some stream sections, particularly in the uppermost mainstem Klickitat and Diamond Fork.

- ***Altered food web – decreased salmon carcasses and subsequent reduction of nutrients.*** Diminishing run sizes limit salmon carcasses, a critical source for marine-derived nutrients, from enriching streams, negatively affecting food availability in the upper watershed.

Primary Limiting Factors identified through EDT Analysis

Yakama Nation Fisheries staff recently identified limiting factors for steelhead in 11 areas of the Klickitat subbasin based on EDT analysis. Results for summer and winter steelhead are combined due to difficulties in distinguishing run timing, abundance, and spawning and rearing areas for the two runs.

To conduct their analysis, Yakama Nation Fisheries scientists grouped EDT reaches that had been previously established during the subbasin planning process into larger spawning areas. They identified 6 major spawning areas and 5 minor spawning areas based on geomorphologic and biological considerations, as well as survey data representing habitat accessible or potentially accessible to anadromous and resident fish.

The spawning areas delineated by Yakama Nation Fisheries staff differ in some respects from those identified by the ICTRT for Middle Columbia River steelhead within the Klickitat subbasin. However, the differences are not substantial in terms of the distribution of relatively contiguous reaches with moderate to high historical production potential. Table II-1 compares the areas delineated by the ICTRT and Yakama Nation. The spawning area delineations diverge primarily in the Yakama Nation's Klickitat Canyon and Upper Middle Klickitat MiSAs. The ICTRT considers Surveyors Creek its own MiSA, which does not contain branched habitat from the mainstem Klickitat River, whereas the Yakama Nation includes lower Surveyors Creek with Klickitat River mainstem reaches above the hatchery in the Klickitat Canyon MiSA. The Yakama Nation's Upper Middle Klickitat MiSA overlaps with the ICTRT's Middle Mainstem MaSA (HUC boundaries) between the Summit and White Creek confluences with the mainstem Klickitat, but does not contain ICTRT-modeled branched intrinsic habitat.

Table II-1. Correlations between ICTRT Major and Minor Spawning Areas for Klickitat Steelhead, and Yakama Nation Fisheries Klickitat Spawning Areas in Order of Priority.

ICTRT Klickitat Steelhead Spawning Areas	YN Klickitat Steelhead Spawning Areas
Upper Mainstem MaSA[6]	Upper Klickitat MaSA
White Creek MaSA	White Creek MaSA
Middle Mainstem MaSA[7]	Middle Klickitat MaSA
Lower Mainstem MaSA	Lower Klickitat MaSA
Upper Little Klickitat MaSA	Upper Little Klickitat MaSA
West Fork Klickitat MaSA	West Fork Klickitat MaSA
Trout Creek MiSA	Trout Creek MiSA
Lower Little Klickitat MiSA	Lower Little Klickitat MiSA
Swale Creek MiSA	Swale Creek MiSA
Surveyors Creek MiSA[8]	*Klickitat Canyon MiSA*
	Upper Middle Klickitat MiSA

Yakama Nation Fisheries staff ran the EDT model using their newly defined MaSAs and MiSAs to identify those areas with the highest restoration or protection potential based on the primary limiting factors acting upon those areas. The EDT run confirmed that the dominant limiting factors by reach previously identified in other assessments were consistent. Table II-2 is a qualitative assessment of the relative combined impact of all limiting factors across all life history trajectories in all stream reaches by MaSA on steelhead survival based on EDT. The scenario modeled was that of "no passage" at Castile Falls, meaning that the habitat above Castile Falls is not yet seeded (current conditions).

In addition to EDT modeling results, field biologists and geomorphologists have identified physical degradations (such as in fluvial geomorphology) that may be contributing to limiting biological production of Klickitat steelhead and may need to be addressed to restore properly functioning conditions in the watershed.

[6] The MaSA identified by Yakama Nation Fisheries staff is similar, but begins at the top of Castile Falls (0.8 RM above the confluence with the West Fork Klickitat).
[7] The Middle Klickitat MaSA identified by Yakama Nation Fisheries staff is relatively congruent with the ICTRT's Middle Mainstem MaSA, but does not include the watershed area between the Summit and White Creek confluences with the mainstem Klickitat.
[8] The Klickitat Canyon MiSA as identified by Yakama Nation Fisheries encompasses the Klickitat River mainstem from the Klickitat Hatchery to the base of Castile Falls and includes Surveyors Creek.

Table II-2. EDT Strategic Priority Summary for Protection and Restoration of Klickitat Steelhead by the Yakama Nation's Identified MaSAs and MiSAs, and Primary Limiting Factors Note: The major and minor spawning areas used in the EDT analysis input were identified by the Yakama Nation Fisheries staff, and differ from those MaSAs and MiSAs identified by the ICTRT for recovery planning purposes (Table II-1 above).

Klickitat River Steelhead
Protection and Restoration Strategic Priority Summary

Spawning area priority			Attribute class priority for restoration																
Major or minor spawning area	Protection benefit	Restoration benefit	*Channel stability*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Klickitat Canyon	◯	○						•							•			
Lower Klickitat	○	○			•		•	●	●	•				•	•	•		•
Lower Little Klickitat	○	○			•		•						•	•	●	●		
Middle Klickitat	◯	○	•		•		•		•	•				•	●			•
Swale Cr.	○	○					•	●	•				●	•	●	◉		●
Trout Cr.							•	●	•						◉	•		•
Upper Klickitat		◯	•					•	•		◉				●	•		•
Upper Little Klickitat	○		•		•		•	•	•		◉		•	•	●	●		•
Upper Middle Klickitat	○		•		•		•		•					•	•			
West Fork Klickitat R.																		
White Cr.	○	◯					•	•	•						●	●		●

Key to strategic priority (corresponding Benefit Category letter also shown)

1/ "Channel stability" applies to freshwater areas only.

A	B	C	D & E
◯ High	○ Medium	○ Low	Indirect or General
●	●	•	

Limiting Factors and Threats in ICTRT Spawning Areas

Tables II-3 through II-12 show the limiting factors and threats identified by Yakama Nation Fisheries biologists within each of the ICTRT's major and minor spawning areas. Information used to identify these factors and threats came from several sources: 1) the analysis completed through the Northwest Power and Conservation Council's 2004 subbasin planning process; 2) the Klickitat Lead Entity process performed under the Washington State Salmon Recovery Planning process, SB2496; 3) and a Yakama Nation 2005 EDT model run incorporating major spawning areas. The tables provide for each area: limiting factors, problem location, VSP parameters and life stages affected, threats, significance and severity of the problem, and actions needed to address the problems.

The "predation" limiting factor is generated from EDT model parameters. Specific predation studies that were used to develop the EDT "predation" attribute and rule making can be found at www.mobrand.com and include Weber and Fausch (2003).

Table II-3. Potential Limiting Factors for Middle Columbia River Steelhead in the Upper Mainstem MaSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor/s	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected	Significance (Scope/Severity)	Actions
Blocked or impaired passage	Spatial structure	Culverts on several tributary streams	Obstruction of juvenile, and possibly adult, movement at culverts.	PM	At least one partial barrier culvert near the mouth of Piscoe Creek and 3 more possible barriers upstream, and a partial barrier near the mouth of McCreedy Creek may be replaced by BIA timber sale improvement plan.	Replace culverts.
Altered sediment routing	Abundance, productivity	Chaparral Creek, McCreedy Creek, Piscoe, Diamond Fork, Coyote, Butte Meadows, Klickitat R. from Castile Falls (RM 65.75) to RM 87.05	Increased road densities and drainage extension; ORV trail use.	E, F	Point source delivery of fine sediment from roads; stream bank mass wasting. High impact in McCreedy, mainstem from RM 71.49-75.36, RM 76.99- 87.05, and Diamond Fork RM 0 - 12.22, in Piscoe Creek and Butte Meadows; moderate impact on F from RM 8.76-12.22 of Diamond Fk., E and F stages in Coyote, and on E in Klickitat mainstem RM 65.78-68.82; extreme impact on E stage in Coyote Creek Actions will decrease run-off/peak flows and sediment introduction, decrease interception and incision of shallow groundwater flows, and restore valley-bottom morphology and potential for channel migration. Spawning and rearing habitat will be improved; egg-to-fry survival will increase.	Disconnect roads from stream network; relocate/ abandon mid-slope roads where possible; relocate/abandon valley-bottom roads where possible. Improve surface and drainage characteristics of roads in tributary watersheds. Riparian forest management and planning: leave buffer strips in riparian forest zones. Reduce fine sediment introduced from streambank mass wasting. Limit riparian livestock grazing.
Degraded water quality, water temperatures	Abundance, productivity	Piscoe Creek, Chaparral Creek, Diamond Fork, Coyote Creek	Road densities; floodplain roads; past grazing.	R0, I0-1, R1, R2+	Lack of riparian canopy and pool habitat. High temperatures during summer low flows and formation of anchor ice in winter caused by lack of cover and pools limit productivity. High impact on R0, R1 in Piscoe and Chaparral; moderate impact in Diamond Fk., in Klickitat mainstem RM 8.76-10.04)., and on I0-1 and R1 in Coyote; moderate impact on R1 and R2+ in upper Diamond Fk. Rearing habitat, juvenile survival will be improved.	Riparian re-vegetation. Restore channel morphology. Disconnect roads from streams. Limit riparian livestock grazing. Eradicate non-native invasive plant species from critical watershed areas.
Channel instability , loss of floodplain function and channel migration processes, degraded riparian condition	Abundance, productivity	Chaparral Creek, Coyote Creek, McCreedy Creek, Butte Meadows Creek, Klickitat R. from Castle Falls (RM 65.75) to RM 87.05, Upper Diamond Fork	Historical grazing; channel confinement due to armoring; streamside ORV trails (avulsion risk), roads, road failures.	S, E, F	Extreme impact on E in Coyote; high in Chaparral, upper Piscoe and upper Diamond Fk., and from RM 75.36 - 87.05; moderate on S and F, and on E in Butte Meadows, from Chaparral to McCreedy, McCreedy Creek and upper Diamond Fork. Actions will lead to improved floodplain connectivity, pool quality, gravel sorting and stability, thus increasing available refugia, improving rearing habitat, and juvenile and egg-to-fry survival.	Relocate/ soften floodplain infrastructure. Perforate roads to allow peak flows to move onto floodplain. Close/relocate ORV trails. Place LWD or other structures to stop headcutting. Vegetate riparian areas. Limit riparian livestock grazing. Eradicate non-native invasive plant species from critical watershed areas.
Reduced key habitat quantity from lost floodplain function and channel migration processes, degraded riparian condition	Abundance, productivity	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	Hydroconfinement; floodplain roads; historical overgrazing. Potential habitat fragmentation.	S, E, F, R0, I0-1, M1, R1, R2+, M2+, PM, PH	High impact on all life stages except TR2+ in upper reach of Diamond Fk.; moderate impact on all except TR2+ (high impact on S, E, PH) in lower Diamond Fk.; moderate on all except TR2+ in upper Piscoe and high impact on PH; moderate impact on E stage in Chaparral and S and E stages in Butte Meadows. Improved side-channel habitat, pool quality and quantity will	Restore floodplain and side-channel connectivity. Restore stream length. Place LWD. Short-term introduction of spawning gravel. Protect existing habitat from future degradation. Limit riparian livestock grazing.

Limiting Factor/s	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected	Significance (Scope/Severity)	Actions
					improve rearing habitat and juvenile growth and survival. Numerous private sections in the upper portion of the Diamond Fork watershed were purchased by a developer. WaDNR parcels that are currently in State Lands could be reclassified as Natural Areas.	
Reduced habitat diversity, riparian condition, floodplain function and channel migration processes	Abundance, productivity	Klickitat River from RM 70.5 to RM 87.05, Piscoe Creek, Diamond Fork, Butte Meadows Creek, Chaparral Creek	See above.	S, F, R0, I0-1, R1, M1, R2+	Moderate impact on S, F, I0-1, M1, R1 in upper Piscoe, lower Diamond Fork; high impact on F and moderate on all I0-1 stages in Coyote Creek, moderate impact on S in Diamond, and S and F in Chaparral.	See above.
Reduced food web	Abundance, productivity	Klickitat River from RM 70.5 to RM 87.05, Chaparral Creek, Diamond Fk., Piscoe Creek	Loss of salmon carcasses.	F, I0-1, R1	Greater impact of reduction in food web on fry colonization in mainstem than in tributaries. Moderate impact on F from Castile to Diamond Fk., lower Chaparral, upper Piscoe, also on I0-1 in lower Diamond Fk. Reducing sediment inputs will increase aquatic insect production for food. Carcass analogs may provide a temporary food source for juveniles. Actions will improve primary and secondary productivity by improving substrate conditions.	Improve channel complexity and connectivity (see above). Short-term fertilization of stream with carcasses or carcass analogs. Decrease fine sediment production and delivery from roads and other land uses.
Harassment/ poaching	Abundance	Upper Klickitat mainstem	Illegal harvest.	S, PH	Infrequent/episodic occurrence but with moderate to high impact when it does occur.	Eliminate illegal harvest by enforcing tribal regulations

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-4. Potential Limiting Factors for Middle Columbia River Steelhead in the White Creek MaSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameter Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Altered hydrology	Abundance, productivity, spatial structure	White Creek to RM 1.46, RM 9,59 - 13.88; Brush Creek; Tepee Creek, and NE tributary to Tepee Creek (less impact than the rest of Tepee Creek)	Past riparian logging; some stream cleaning; floodplain roads.	F, R0, I0-1, R1	Channel incision resulting in reduced perennial and hyporheic flows; scour of spawning gravels, incision related to increased peak flows. Reduced LWD. Moderate impact on F in White Creek RM 0 -1.46, RM 2.40 - 13.88, upper Tepee, in NE trib. and W. Fk.; moderate on R0 in White Creek RM 2.40 m – 10.6., in Brush and Tepee; moderate on I0-1 in Brush from RM 3.46 – 8.03, in White Creek RM 4.86-9.59, RM 10.42 – 13.88, in NE trib., to RM .19, in Tepee from RM 3.58-9.91; moderate on R1 in White Creek RM 4.86-9.59 and R, 10.42-10.60. Egg-to-smolt survival ratio is closely related to summer flow conditions.	Restore floodplain connectivity; increase floodplain and channel roughness. Disconnect road network to improve watershed and water retention.
Reduced key habitat quantity, floodplain function and channel migration processes, degraded riparian condition	Abundance, productivity, spatial structure	White Cr to RM 1.46, RM 2.4 - RM 16.3; Brush Creek; Tepee Creek	Past riparian logging; some stream cleaning; road densities and floodplain roads. Potential habitat fragmentation via subdivision, land-clearing, and development.	S, E, F, R0, I0-1, M1, R1, R2+, M2+, PM, PH	Channel simplification and disconnected floodplain side-channels due to incision. Reduced LWD. Increased run-off. High impact on S and E in White Creek RM 0 -1.46 and in Brush Creek to RM 3.46; on S, E, F and R0 in White RM 10.42-13.88, and E, F, R0 in Brush Creek RM 3.46-8.03, , in Tepee (also on PH) and upper White; moderate impact on other affected stages in Brush, upper White and Tepee. Loss of spawning gravel (habitat) below Brush Creek due to scouring. Rearing limited from Brush Creek to above the IXL road. Lack of perennial flows. Actions would reduce incision; restore channel roughness and complexity to better handle peak flows and augment base flows; increase pool abundance and rearing capacity; improve sorting of sediments and gravel retention. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Disconnect road network to improve watershed and water retention. Place LWD. Augment gravel. Excavate pools. Restore floodplain connectivity. Limit riparian livestock grazing. Protect existing habitat from future degradation.
Reduced habitat diversity, lost floodplain function and channel migration processes	Abundance, productivity	White Creek to RM 1.46, RM 4.86 - 16.3; Tepee Creek; W. Fork White Creek	Primarily road densities and floodplain roads. Potential habitat fragmentation via subdivision, land-clearing, and development.	S, F, R0, I0-1, R1, M1, R2+, M2+	Channel simplification and disconnected floodplain due to incision. Reduced LWD, increased run-off. High impact on F in White Creek RM 4.86 - 9.59; moderate impact on S, F, R0 and I0-1 in White Creek to RM 1.46 and RM 2.40 – 4.86; moderate also on I0-1, R1, M1, R2+, M2+ RM 4.86-9.59. Loss of spawning and rearing habitat.	Investigate off-channel livestock watering in Tepee Creek Improve pool: riffle ratio; add LWD; increase riparian cover; add spawning gravel. Increase floodplain connectivity by correcting channel incision and relocating or modifying floodplain roads. Protect existing habitat from future degradation.

Limiting Factor	VSP Parameter Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Blocked or impaired passage	Abundance, spatial structure	White Creek RM 4.86 -9.59; Tepee Creek; NE tributary to Tepee Creek; Fork White Creek	Inadequate culvert sizing and installation at 2.7 miles upstream of IXL road crossing in upper White Creek	E, R0, R1, R2+, (to a lesser degree M1, M2+), TR2+	Upstream movement of juveniles from rearing habitat to perennial refugia limited. Moderate impact.	Culvert replacement.
Altered sediment regime	Abundance, productivity	White Creek to RM 1.46, RM 9– headwaters; Brush Creek; NE tributary to Tepee Creek; W. Fork White Creek	Point source delivery of fine sediment associated with road drainage.	S, E, I0-1	High impact on E in upper Brush, White Creek RM 9 - headwaters, in Tepee, NE Trib., and W. Fork, moderate in upper White and lower Brush. Potential additional minor contribution of sediment from aerial deposition due to road traffic.	Improve road drainage characteristics and surfacing. Disconnect roads from stream. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones. Address fine sediment introduction from streambank mass wasting by modifying channel morphology and restoring floodplain connectivity
Degraded water quality, water temperature	Abundance, productivity, spatial structure	White Creek to RM 1.46; RM 4.86 - RM 16.3; Brush Creek; Tepee Creek; W. Fork White Creek	Past riparian logging; some stream cleaning; Land use practices that increased run-off (primarily from road densities) and floodplain roads; channel incision.	S, E, F, R0, R1, R2+	Reduced perennial and hyporheic flows, reduced riparian canopy. Reduced LWD. Extreme impact on E in upper Brush; high impact on E in the mouth of White Creek and from Brush Creek to ~16 mi. upstream, in W. Fork, Tepee, and upper Brush; also extreme on S and R0 and high impact on E, F, R1 and R2+ life stages in W. Fork White to RM 1.91	Restore floodplain connectivity. Re-vegetate riparian zone and floodplain. Eradicate non-native invasive plant species from critical watershed areas.
Reduced food web	Abundance, productivity	White Creek to RM 1.46, RM 9.59 - RM 13.88; Brush Creek; Tepee Creek; NE tributary; W. Fork White Creek	Reduced LWD from past riparian logging, some stream cleaning; increased run-off (primarily from road densities) and floodplain roads.	F, R0, I0-1, R1	Potential reduction in macroinvertebrate densities due to low flows or lack of perennial flow upstream and high fine sediment load. High impact on F in upper Tepee; moderate impact on F in lower White, lower Brush, lower Tepee, White from Brush to ~16 mi. upstream and in lower W. Fork; moderate on I0-1 from bottom of 1st meadow to Tepee, (also on R1) in upper Tepee	Restore floodplain connectivity. Disconnect road network to improve watershed and water retention. Improve road drainage characteristics and surfacing. Place LWD. Increase pool quantity and quality; improve pool/riffle ratio. Augment gravel. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones. Investigate off-channel livestock watering in Tepee Creek Place carcass analogs.
Reduced floodplain function and channel migration processes, channel stability	Abundance, productivity	Mainstem White from ~RM 3 to IXL Road; Tepee Cr from mouth to ~RM 10; Brush Creek from mouth to ~RM 8.	Channel incision.	E, F, I0-1	Moderate impact on affected life stages.	Restore floodplain connectivity, profile and cross-sectional morphology. Decrease amount of water delivered to stream network by roads.

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-5. Potential Limiting Factors for Middle Columbia River Steelhead in the Middle Mainstem MaSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Altered sediment routing	Abundance, productivity	Klickitat R. from Little Klickitat River to Dead Canyon. (RM 20.44 – RM 31.46); Dead Canyon; Beeks Canyon; Summit Creek; Klickitat R. from Summit Creek to White Creek (RM 37.73 – 40.27)	Increased road densities and drainage extension; delivery of fine sediment from upstream tributaries (primarily glacial, but also from road runoff).	E, F, I0-1, R0, R1, R2+, TR2+	High impact on E, F, I0-1 in mainstem from Beeks to Summit, Dead Canyon, Summit; moderate from Little Klick to Beeks. Road densities contribute to turbidity and clog interstitial spaces, interfering with rearing and feeding.	Disconnect road network from streams. Improve road surface and drainage. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones.
Reduced key habitat quantity, reduced floodplain function and channel migration processes	Abundance, productivity	Klickitat R. from Little Klickitat R. to Summit Creek (RM 20.44-RM 37.73), Summit Creek to Hatchery (RM 37.73 – 42.5); Dead Canyon, Summit Creek	Hydroconfinement. Habitat fragmentation via subdivision, land-clearing, and development.	S, E, F, R0, I0-1, M1, R1, R2+, M2+, PH	Channel simplification and disconnected side-channels. Reduced LWD. High impact on S and E in Beeks and Summit, on E, F and R0 in Dead Canyon; moderate impact in Klickitat R. from RM 20.44-31.46; moderate on S and F in lower Dead Canyon, on R1, PM and holding in Dead Canyon RM 5-3.54, moderate on PH from RM 20.44-37.73 in mainstem Klickitat. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore floodplain and side-channel connectivity. Restore stream length. Short-term introduction of spawning gravel. Place LWD. Protect existing habitat from future degradation.
Reduced habitat diversity, loss of floodplain function and channel migration processes	Abundance, productivity	Klickitat R. from Little Klickitat River to Summit Creek (RM 20.44-RM 37.73) and Summit Creek to Hatchery (RM 37.73 – 42.5); Dead Canyon	Hydroconfinement; floodplain infrastructure; historical overgrazing. Habitat fragmentation via subdivision, land-clearing, and development.	S, F, R0, I0-1, R1, M2+	Channel simplification and disconnected side-channels. Moderate impact on S and F in mainstem Klickitat RM 20.44- 25.95 and Summit Creek, moderate on F in lower Dead Canyon; moderate on F, R0 and I0-1 in Dead Canyon RM 2.55-3.54. Actions would create refugia. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore floodplain and side-channel connectivity. Restore stream length. Short-term introduction of spawning gravel. Place LWD. Protect existing habitat from future degradation.
Degraded water quality, water temperature	Abundance, productivity	Beeks Canyon; Dead Canyon to RM 2.55	Road densities, floodplain roads; possibly some grazing and past riparian logging impacts.	S, E, F, R0	Lack of riparian canopy and pool habitat; reduced perennial and hyporheic flows, sediment load. High impact on E in Beeks, moderate in Dead Canyon, moderate on S from RM 31.46-37.73 in the mainstem Klickitat	Riparian re-vegetation. Eradicate non-native invasive plant species from critical watershed areas. Restore channel morphology. Disconnect roads from streams. Obtain instream flow right for mainstem Klickitat.
Harassment/ poaching	Abundance	Klickitat R. from Little Klickitat R. to	Post-release mortality from fishing, poaching of wild fish, by-	S, PH, PM	Moderate impact	Enforcement of fishing regulations, tackle restrictions, shorter sport

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
		Summit Creek (RM 20.44-RM 37.73);	catch during whitefish season			season
Altered hydrology	Abundance, productivity	Dead Canyon; Summit Creek (also Beeks Canyon historically)	Reduction in forest canopy; incision of headwater (non-fish-bearing) reaches; reduced forest and floodplain storage.	F, R0	Altered watershed hydrology; shorter flow duration (low flows), higher peak flows, and increased incision. High impact on R0 in lower Dead Canyon, moderate on F and R0 in Dead Canyon RM 2.55-3.54 (low flows); I0-1 stages affected by higher peak flows.	Restore floodplain connectivity. Disconnect road network to improve watershed and water retention.
Predation	Abundance, productivity	Little Klickitat River to Summit Creek (RM 20.44-RM 37.73); Summit Creek to Hatchery (RM 37.73 – 42.5)	High density of hatchery-origin smolts; dewatering.	F, R0	Dewatering intensifies impact from avian and terrestrial predators. Moderate impact	Change stocking practices with regards to numbers, location and timing of smolt outplanting. Research interaction with hatchery fish, native and non-native predators.
Competition with hatchery fish	Abundance, productivity	Klickitat R. from Little Klickitat R., to Summit Creek (RM 20.44-RM 37.73), Summit Creek to Hatchery (RM 37.73 – 42.5)	High density of hatchery-origin smolts (coho, fall Chinook salmon and steelhead); size of *O.mykiss* smolts released; fall Chinook salmon releases may also be an issue.	R0, R1, R2+	Moderate impact. R0 affected by fall Chinook salmon releases.	See above.
Channel instability, loss of floodplain function and channel migration processes; degraded riparian condition	Abundance, productivity	Klickitat R. from Little Klickitat River to Summit Creek (RM 20.44-RM 37.73), Summit Creek to Hatchery (RM 37.73 – 42.5)	Channel confinement; armoring of embankment adjacent to road.	S, E	Channel confinement: stream too (artificially) stable laterally causing vertical instability. Moderate impact	Relocate/soften floodplain infrastructure. Perforate roads to allow peak flows to move onto the floodplain. Place LWD or other structures to stop headcutting. Vegetate riparian areas. Eradicate non-native invasive plant species from critical watershed areas. Close/relocate ORV trails.
Blocked or impaired passage	Abundance	Tributary mouths	Lack of access to spawning tributaries.	PM	High impact in low water years; likely occurred naturally, but human impacts have likely increased frequency	Study passage at tributary mouths relative to flow and alluvial fan morphology.

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-6. Potential Limiting Factors for Middle Columbia River Steelhead in the Lower Mainstem MaSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Reduced key habitat quantity, loss of floodplain function and channel migration processes; degraded riparian condition	Abundance, productivity	Klickitat R. to top of Bonneville Pool (to RM 1.19); Snyder Creek to RM 1.57	Inundation by Bonneville Pool, anthropogenic influences e.g. hydroconfinement, alteration of riparian zone by road, railroad prism and Snyder Creek mill complex; habitat fragmentation via subdivision, land-clearing, and development.	S, E, F, I0-1, R1, R2+, M2+, PH, PM	Extreme impact on I0-1, R1, R2+ in impounded lower reach of Klickitat R. to RM 1.19; extreme impact on PH and high impact on F, I0-1, R1, R2+, M2+ and PM in Snyder Creek to RM .58; high impact on S, E and PH in Snyder within mill flume reach. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Encourage dam operations that mimic natural flow regimes. Restore floodplain and channel connectivity. Place LWD. Monitor and continue restoration efforts in Snyder Creek mill reach (flume passage improvements and riparian re-vegetation). Protect existing habitat from future degradation. Eradicate non-native invasive plant species from critical watershed areas.
Reduced habitat diversity, loss of floodplain function and channel migration processes; degraded riparian condition	Abundance, productivity	Klickitat R. to top of Bonneville Pool (to RM 1.19), RM 5.72 – 9.72, RM 11.29 - 20.44; Snyder Creek	Inundation by Bonneville Pool, channel simplification due to hydroconfinement by road and railroad prism; habitat fragmentation via subdivision, land-clearing, and development.	S, F, R0, I0-1, M1, R1, R2+ and M2+	Extreme impact on I0-1 and R1 and high impact on R2+ and moderate on M1 and M2+ in the Klickitat R. below RM 1.19; high impact on S and F between Snyder and Swale Cr RM 14.63-17.88; and on F in Snyder to RM .58; moderate on S, F, R0 in the Klickitat R. RM 11.29 - 14.63 , and for M1 and M2+ in the mainstem to RM 1.19; moderate on I0-1 and R1 from Lyle Falls to Logging Camp Canyon RM 2.61 – 9.72, and on S, F, and R0 from Wheeler to Snyder RM 11.29 – 14.63; moderate on S, R0, I0-1, R1, R2+, and M2+ in Snyder to RM .58, and on S, F and R0 RM .58 – 1.57 ; moderate on R0, I0-1, M1, R1 and M1 from Snyder to Swale Creek RM 14.63 – 17.88. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	See above.
Reduced food web	Abundance, productivity	Snyder Creek; Klickitat R. to top of Bonneville Pool (to RM 1.19)	Inundation by Bonneville Pool; hydroconfinement.	F, R0, I0-1, R1	Reduced benthic community; channel simplification. Extreme impact on F, R0, I0-1, R1 in Snyder Creek; moderate impact on I0-1 and R1 from mouth of Klickitat to top of Bonneville Pool at RM 1.19.	Encourage dam operations that mimic natural flow regimes. Restore floodplain and side-channel connectivity. Place LWD.
Degraded water quality, water temperatures	Abundance, productivity	Snyder Creek	Mill site; roads and past grazing practices in headwaters.	F, R0	Reduced riparian canopy in mill reaches and reduced hyporheic flows. High impact on affected life stages in Snyder Creek	Restore channel morphology. Re-vegetate riparian areas. Eradicate non-native invasive plant species from critical watershed areas.
Altered sediment routing	Abundance, productivity	Mainstem Klickitat from Snyder Creek to Little Klickitat R.	Headwater forest practices and roads.	E	Moderate increase in fine sediment delivery over background levels. High impact from Snyder to Little Klickitat RM 14.63 – 20.44, upper Snyder; moderate	Disconnect roads from stream network; relocate/ abandon mid-slope roads where possible; relocate/abandon

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
		(RM 14.63 – 20.44), Snyder Creek (RM .58 – RM 1.57)			impact Wheeler to Snyder RM 11.29-14.63.	valley-bottom roads where possible. Improve surface and drainage characteristics of roads in tributary watersheds. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones.
Predation	Abundance, productivity	Klickitat R. to top of Bonneville Pool (to RM 1.19), from Wheeler Canyon to Little Klickitat R. (RM 11.29-20.44)	Increased densities of native and non-native predators in Bonneville Pool reach; hatchery stocking practices.	F, I0-1, M1, R1, M2+	High densities of hatchery outplants. Moderate impact on affected life stages in Klickitat mouth; and on F from Wheeler to Little Klickitat R.	Change stocking practices with regards to numbers, location and timing of smolt outplanting. Research interaction with hatchery fish, native and non-native predators.
Competition with hatchery fish	Abundance, productivity	From top end of Bonneville pool to Little Klickitat R. (RM 1.19 – 20.44)	High densities of hatchery outplants.	R1, R2+	Moderate impact	See above.
Blocked or impaired passage	Abundance, spatial structure	Mouths of spawning tributaries	Altered hydrograph; channel morphology	R0, R1, R2+	In low precipitation years there is often insufficient flow for adult passage through alluvial fans of spawning tributaries.	Study passage relative to flow and alluvial fan morphology.
Channel instability, loss of floodplain function and channel migration processes	Abundance, productivity	Mainstem Klickitat	Roads	E, F, I0-1	Confinement has contributed to incision and bed coarsening.	Restore floodplain connectivity.
Impaired passage	Productivity	Mainstem Klickitat	Unscreened pump intakes	F, R0, R1	Increases juvenile mortality	Ensure that pump intakes are adequately screened. Determine extent of problem for inadequately screened intakes.
Altered hydrology	Abundance, productivity, spatial structure, diversity	Mainstem Klickitat and tributaries	Dewatering in tributaries. Future water demand for out-of-channel use in mainstem.	S, R0, R1, R2+	Dewatering is currently a problem in tributaries and potential future problem in mainstem.	Obtain instream flow right for mainstem Klickitat. Restore floodplain connectivity in tributaries. Assess effects of groundwater development on tributary flow.
Harassment/ poaching	Abundance	Mainstem, tributaries	Poaching.	PM	Moderate and periodic problem	Reduce/eliminate poaching by both sport and tribal fishermen. Further restrict sport fishing in lower basin tributaries, e.g. Logging Camp Creek.

Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-7. Potential Limiting Factors for Middle Columbia River Steelhead in the Upper Little Klickitat MaSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Reduced habitat diversity, degraded floodplain function and channel migration processes	Abundance, productivity	Spring Creek, W. Prong, E. Prong, Little Klickitat R. from Spring Creek to Cozy Nook (RM 9.02 – 20.34)	Hydroconfinement and channel incision; roads; grazing and forest practices; habitat fragmentation via subdivision, land-clearing, and development.	S, F, R0, I0-1, M1, R1, M2+	Disconnected side-channels and channel simplification; reduction in LWD. Moderate impact on affected life stages. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore side-channel and floodplain connectivity. Excavate pools. Place LWD. Augment gravel. Protect existing habitat from future degradation. Eradicate non-native invasive plant species from watershed areas.
Altered hydrology	Abundance, productivity	Little Klickitat R. from Spring Creek to W. Prong (RM 9.02-26.61); Spring Creek to RM 3.53; Bloodgood Creek; W. Prong; E. Prong; Butler Creek; Dry Creek	Diversions; road densities.	F, R0, I0-1, R1	Channel simplification, channel incision and disconnected floodplain side-channels; reduced perennial and hyporheic flows. Moderate impact on affected life stages in lower Spring Creek and upper Little Klickitat watershed	Manage diversions to maximize instream summer flows. Disconnect roads from stream. Improve road drainage characteristics and surfacing.
Altered sediment routing	Abundance, productivity	Spring Creek, Bloodgood Creek to RM 2.23, W. Prong; E. Prong; Little Klickitat R. from Spring Creek to W. Prong (RM 9.02-26.61); Butler Creek; Dry Creek	Increased road densities in headwater tributaries and untreated forest road segments; runoff from agricultural lands.	S, E	Runoff, surface and re-distribution of in-channel fine sediment in the form of bank mass wasting; delivery of fine sediment from upstream tributary sources; agricultural sediment in Spring Creek, unnamed tributaries to Spring Creek, and Little Klickitat R. from Spring Creek to Bloodgood (downstream of Goldendale). Extreme impact on E in lower Spring and lower Bloodgood, in lower Klickitat R. from Cozy Nook to ~RM 24, W. Prong, and E. Prong from Dry Creek to Idlewild Canyon RM 2.73 – 4.81, Butler and Dry Creek; high impact on E RM 15.46 – 20.34, from ~RM 24 to W. Prong; mouth of E. Prong	Disconnect roads from stream. Reduce sediment inputs. Improve road drainage characteristics and surfacing. No-till cropping. Promote riparian buffers. Restore floodplain connectivity/channel morphology; decrease mass wasting of banks.
Degraded water quality, water temperatures	Abundance, productivity	Little Klickitat R. from falls to Hwy 97 (RM 6.38 – RM 26.68); Spring Creek; E. Prong; W. Prong	Roads; grazing; lack of riparian cover.	F, R0, R1, R2+, TR2+	Reduction in base flows and canopy cover, change in channel morphology (width to depth ratio). High to extreme impact on F and R0 in mainstem Little Klickitat from Spring Creek to W. Prong; high impact on R1 from Cozy Nook to ~RM 24; moderate impact on S from Spring Creek to Hwy. 97	Re-vegetate riparian areas. Increase riparian cover. Leave riparian buffer. Limit riparian grazing. Eradicate non-native invasive plant species from critical watershed areas. Restore floodplain connectivity and channel morphology.

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Reduced key habitat quantity, floodplain connectivity and function	Abundance, productivity	Little Klickitat R.; W. Prong; E. Prong; Butler Creek	Primarily past riparian management; habitat fragmentation via subdivision, land-clearing, and development.	S, E, F, I0-1, PH,	Channel simplification and disconnected floodplain side-channels due to incision. High impact on S, E ~RM 24 to 26.6 and in W. Prong, E. Prong and Butler to Hwy. 97; rearing stages affected downstream of approximately Cozy Nook Creek; impact on S upstream of there. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore side-channel and floodplain connectivity. Excavate pools. Place LWD. Augment gravel. Protect existing habitat from future degradation.
Degraded water quality, pathogens	Abundance	Little Klickitat R. from Spring Creek to Idlewild Canyon (RM 9.02 – RM 4.81 on E. Prong); Spring Creek to RM 3.53; Butler Creek	Hatchery stocking; riparian grazing; anecdotal indications of illegal stocking of rainbow trout in tributaries to the Little Klickitat R.	R0, R1, R2+, TR2+	Presence of hatchery fish. Elevated stream temperatures. High impact in Little Klickitat from Cozy Nook to ~RM 24, in E. Prong from Butler to Dry Creek, moderate impact elsewhere	Re-vegetate riparian areas to reduce stream temperatures. Increase riparian cover. Leave riparian buffer. Limit riparian grazing. Restore floodplain connectivity and channel morphology. Curtail hatchery releases.
Predation	Abundance, productivity	Spring Creek to RM 3.53, Little Klickitat from Spring Creek to Idlewild (RM 9.02 – RM 4.81 on E. Prong); W. Prong; Bloodgood Creek to RM 2.23; Butler Creek	Increased number of fish taxa present; hatchery outplants and dewatering may be factors in the mainstem.	F, R0	Reduced summer base flows (stranding); lack of refugia, cover habitat. Moderate impact on F in all affected reaches; also on R0 from Butler to Dry Creek	Change stocking practices with regards to numbers, location and timing of smolt outplanting. Research interaction with hatchery fish, native and non-native predators.
Blocked or impaired passage	Abundance, spatial structure	West Prong at RM .07, RM 21.16; E. Prong at RM 25.41, RM 18.4 on Jenkins Cr;., RM 21.35 on Butler Creek, RM 23.99 on Dry Creek, and RM 25.59 on Idlewild Canyon Creek	Box culverts under highway impede upstream fish passage.	PM, R0, R1, R2+, TR2+,	Extreme impact at box culvert barrier under Hwy. 97 at RM .07; varying passage at other culverts may present limited impediments to fish passage in good water years.	Replace culverts.
Reduced food web	Abundance, productivity	Little Klickitat R. from Spring Creek to Idlewild (RM 9.02 – RM 4.81 on E. Prong); Spring Creek to RM 3.53; Bloodgood Creek; W. Prong, Butler Creek; Dry Creek	Agriculture and grazing practices.	F, I0-1, R0, R1	Reduction in benthic community; nutrient enrichment, elevated temperatures and fine sediment delivery. High impact on F in mouth of Bloodgood, and from there to Cozy Nook in mainstem L. Klickitat; high also on F in Dry Creek from Hwy. 97 to ~ RM 2.5 and in E. Prong from Dry Creek to Idlewild.	Restore floodplain connectivity and channel morphology. Disconnect roads from stream. Reduce sediment inputs. Improve road drainage characteristics and surfacing. No-till cropping. Promote riparian buffers. Increase riparian cover. Investigate off-channel livestock watering.

Limiting Factor	VSP Parameters Impacted	Affected Sites	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Competition with hatchery fish	Abundance, productivity	Little Klickitat R. from Bloodgood Creek to Cozy Nook Creek (RM 15.46 – 20.34); Bloodgood Creek to RM 2.23	Resident rainbow stocking from Goldendale Hatchery.	R0, R1, R2+	Moderate impact on active rearing life stages	Modify hatchery outplant practices with regard to number, location and timing of smolt releases.
Channel instability, loss of floodplain function and channel migration processes; degraded riparian condition	Abundance, productivity	Spring Creek, Little Klickitat R. from Spring Creek to Cozy Nook (RM 9.02 – 20.34); Bloodgood Creek to RM 2.23, W. Prong; E. Prong from W. Prong to Idlewild (RM 0 – 4.81)	Hydroconfinement, active historical stream clearing in upper tributaries; hardened banks on road segments, infrastructure and bank armoring in agricultural lands.	E, F	High impact on E in lower Spring Creek, mouth of Bloodgood, W. Prong to RM 1.93, and in E. Prong from Dry Creek to Idlewild	Restore floodplain connectivity and channel morphology. Place LWD or other structures to stop headcutting. Vegetate riparian areas. Perforate roads to allow peak flows to move onto floodplain.
Impaired fish passage	Productivity	Throughout MaSA	Unscreened pump intakes.	F, R0, R1	Extent of problem needs to be researched.	Ensure that pump intakes are adequately screened. Determine extent of problem for inadequately screened intakes.
Degraded water quality, oxygen	Abundance, productivity, spatial structure	Primarily downstream of Goldendale	Insufficient oxygen in mainstem Little Klickitat River.	R0, R1, R2+	Needs to be monitored and assessed.	Assess nutrient and dissolved oxygen levels in Little Klickitat River, primarily downstream of Goldendale

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-8. Potential Limiting Factors for Middle Columbia River Steelhead in the West Fork Klickitat MaSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Blocked or impaired passage	Abundance, spatial structure	Natural barriers at RM .45 and 4.43	Naturally occurring	PM	Passage and spawning frequency of this watershed largely undocumented, assumed to be minimal	Collect more data on passage frequency and spawner distribution
Altered sediment routing	Abundance, productivity	Roaded portions of MaSA	Sediment delivery from upstream road failures	E, I0-1	Protect streams from adverse effects of forest practices (particularly roads).	Prevent introduction of road-derived sediment; replace undersized crossings; disconnect roads from streams.

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-9. Potential Limiting Factors for Middle Columbia River Steelhead in the Swale Creek MiSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Degraded water quality, water temperatures	Abundance, productivity	Swale Creek mouth to S. tributary at RM 12	Railroad prism in floodplain.	S, E, F, R0, M1, R1, M2+, PM	Reduced riparian canopy, reduced perennial and hyporheic flows due to altered channel morphology and disconnected floodplain. Extreme impact on E stages and high on F and R0 in whole section; high on M1, R1 to RM 8, moderate there to RM 12; moderate impact on spawners throughout	Re-vegetate riparian areas. Eradicate non-native invasive plant species from critical watershed areas. Restore channel morphology.
Reduced key habitat quantity, floodplain function and channel migration processes	Abundance, productivity	Swale Creek mouth to S. tributary at RM 12	Railroad prism in floodplain. Habitat fragmentation via subdivision, land-clearing, and development.	All stages except TR2+	Channel simplification and lack of riparian vegetation to provide cover and recruit wood (creates pools for holding and rearing habitat and sorts substrate for spawning habitat).High impact on F and R0 to RM 4 (moderate on all other life stages in this reach); extreme on F and high on E, R0, M1,R1 and PH RM ~4-8, high impact on S, E, F and R0 ~RM 8-12. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Place LWD. Excavate pools. Augment gravel. Restore floodplain connectivity. Protect existing habitat from future degradation.
Altered sediment routing	Abundance, productivity	Swale Creek mouth to NW tributary at ~RM 8	Sediment delivery from agricultural sources in the highlands of the Swale Creek Basin.	E	High impact to RM 8	Promote no-till cropping and riparian buffers in agricultural areas.
Degraded water quality, pathogens	Abundance	Swale Creek mouth to S. tributary at RM 12	Hatchery stocking practices: presence of hatchery-origin fish (spawning and rearing coho/steelhead); railroad prism in floodplain.	R0	High density of hatchery-origin fish. Elevated stream temperatures due to lack of canopy cover, instream structure. Reduction in LWD related to railroad prism. High impact throughout the section	Re-vegetate riparian areas to reduce stream temperatures. Change stocking practices with regards to numbers, location and timing of smolt outplanting. Conduct pathogen sampling and monitoring.

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Reduced food web	Abundance, productivity	Swale Creek mouth to S. tributary at RM 12	Railroad prism in floodplain.	F, R0, I0-1, R1	Potential reduction in macroinvertebrate densities; channel simplification, intermittent flows and high temperatures. High impact on F from ~RM 4-8 and moderate impact in other reaches; moderate impact on other affected stages from ~RM 4-8	Re-vegetate riparian areas. Eradicate non-native invasive plant species from critical watershed areas. Restore channel morphology. Place LWD. Excavate pools. Augment gravel. Restore floodplain connectivity.
Reduced habitat diversity, degraded floodplain function and channel migration processes	Abundance, productivity	Swale Creek mouth to S. tributary at RM 12	Hydroconfinement; railroad prism in floodplain; habitat fragmentation via subdivision, land-clearing, and development.	S, F, R0, I0-1, M1, R1, TR2+ M2+	Disconnected side-channels and channel simplification; channel incision; reduction in LWD. High impact on F between ~RM4-; moderate impact on S and F to RM ~4; moderate on S, R0, I0-1, M1, R1, and M2+ ~RM 4-8; moderate on S, F and R0 ~RM 8-12. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore floodplain and side-channel connectivity. Place LWD. Excavate pools. Augment gravel. Protect existing habitat from future degradation.
Predation	Abundance, productivity	Swale Creek mouth to S. tributary at RM 12	Hatchery stocking practices; loss of cover.	F, R0	High density of hatchery-origin fish; reduction in LWD and pools for cover. Moderate impact in whole section	Increase LWD and pool hiding cover. Change stocking practices with regards to numbers, location and timing of smolt outplanting. Research interaction with hatchery fish, native and non-native predators.
Altered hydrology	Abundance, productivity	Swale Creek mouth to S. tributary at RM 12	Upstream diversions (irrigation season); railroad prism in floodplain.	F, R0, I0-1, R1	Reduced summertime base flows, channel incision, reduced perennial and hyporheic flows; increased peak flows. Reduced LWD. Moderate impact on F and R0 to ~RM 4; moderate on F, R0, I0-1, and R1 ~RM 4-8; moderate on F ~RM 8-12	Reconnect floodplain. Manage diversions to maximize instream summer flows.
Channel instability, loss of floodplain function and channel migration processes	Abundance, productivity	Canyon reach.	Incision and channel instability.	I0-1, R0, R1, R2	Degraded habitat, low pool frequency and quality.	Restore cross-sectional morphology and roughness. Modify historical railroad grade. Modify land-uses and/or implement structures to retain storm flow and decrease time of concentration from watershed upstream of canyon.

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-10. Potential Limiting Factors for Middle Columbia River Steelhead in the Surveyor's Creek MiSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Location of Impacts	Threats	Life stages affected*	Significance (Scope/Severity)	Actions
Altered sediment routing	Abundance, productivity	Klickitat R. from Big Muddy Creek to Castile Falls step pool habitat (RM 54.87– 65.42); Trout Creek to RM 1.09, Bear Creek, Surveyors Creek	Increased road densities and drainage extension.	S, E, F, I0-1	Point source delivery of fine sediment from upstream tributary sources. Moderate impact on S & E from Big Muddy to Surveyors, on S in Surveyors from cascade barrier to Cedar Creek and from Surveyors to step pool habitat within Castile cascades; and on E in Trout Creek from mouth to cascades	Disconnect roads from stream network; relocate/ abandon mid-slope roads where possible; relocate/abandon valley-bottom roads where possible. Improve surface and drainage characteristics of roads in tributary watersheds. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones.
Reduced food web	Abundance, productivity	Klickitat R. from Trout Creek to Castile step pool habitat (RM – 65.42); W. Fork Klickitat below falls (RM .45)	Reduction in salmon carcasses (spring Chinook salmon).	F, R1, I0-1	Moderate impact from Trout Creek to Surveyors and from Soda Springs to step pool habitat within Castile cascades, lower W. Fork	Fertilize stream with carcasses or carcass analogs

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0-1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage

Table II-11. Potential Limiting factors for Middle Columbia River Steelhead in Lower Little Klickitat MiSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
Degraded water quality, water temperatures	Abundance, productivity	Little Klickitat R. to RM 1.24, from Mill Creek to L. Klickitat Falls (RM 3.75-6.38); Canyon Creek; Bowman Creek	Upstream diversions and channel morphology; past grazing; floodplain road; upper watershed grazing; possible dewatering in upper reaches of Canyon Creek	S, E, F, R0, R1	Reduction in base flows. Reduced canopy cover upstream and in lowermost section of Little Klickitat R. around Hwy. 142 bridge and where road parallels Bowman Creek High impact on R0, R1 and E in lower Little Klickitat, on S, E and F between Canyon and Little Klickitat Falls, high on E in Bowman from mouth to falls. Moderate impact on S in Little Klickitat to falls.	Restore floodplain connectivity and channel morphology, riparian vegetation in upper watershed.
Degraded water quality, pathogens	Productivity	Little Klickitat R. to L. Klickitat Falls (RM 6.38); Bowman Creek	Hatchery stocking; grazing in upper watershed.	R0	Elevated stream temperatures exacerbated by lack of riparian cover. Moderate impact	Re-vegetate riparian areas to reduce stream temperatures in upper watershed. Change stocking practices with regards to numbers, location and timing of smolt outplanting. Conduct pathogen sampling and monitoring.
Altered sediment routing	Abundance, productivity	Little Klickitat R. to L. Klickitat Falls (RM 6.38); Canyon	Increased road densities in headwater tributaries and untreated forest road segments,	E	Runoff, surface and re-distribution of in-channel fine sediment in the form of bank mass wasting; delivery of fine sediment from	Disconnect roads from stream. Reduce sediment inputs. Improve road drainage characteristics and surfacing. No-till cropping. Promote riparian

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/Severity)	Actions
		Creek; Bowman Creek	agricultural run-off.		upstream agricultural and tributary sources. Extreme impact in lower Canyon and Bowman, high impact in mouth of Little Klickitat	buffers. Restore floodplain connectivity.
Reduced food web	Productivity	Little Klickitat to RM 1.24	Nutrient enrichment; agricultural practices and grazing.	F, I0-1, R1	Reduction in benthic community. Elevated temperatures and fine sediment delivery. Moderate impact	Actions in upper watershed to affect limiting factors in lower watershed: Restore floodplain connectivity and channel morphology. Disconnect roads from stream. Reduce sediment inputs. Improve road drainage characteristics and surfacing. No-till cropping. Promote riparian buffers. Increase riparian cover. Eradicate non-native invasive plant species from critical watershed areas. Investigate off-channel livestock watering.
Reduced key habitat quantity, loss of floodplain function and channel migration processes	Abundance, productivity	Canyon Creek	Hydroconfinement. Habitat fragmentation via subdivision, land-clearing, and development.	S, E	Channel simplification and reduced riparian function. Moderate impact. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore floodplain connectivity. Place LWD. Short-term introduction of spawning gravel. Protect existing habitat from future degradation.
Predation	Abundance, productivity	Little Klickitat R. to L. Klickitat Falls (RM 6.38); Canyon Creek; Bowman Creek to RM .15	Hatchery stocking practices; dewatering.	F, R0, I0-1, M1, M2+	Predation is hypothesized by EDT model. High density of hatchery-origin smolts due to stocking of catchable rainbow trout from Goldendale Hatchery in Little Klickitat R. and anadromous stocks in mainstem Klickitat R. Dewatering intensifies impact from avian and terrestrial predators. Moderate impact in all affected reaches	Change stocking practices with regards to numbers, location and timing of smolt outplanting. Research interaction with hatchery fish, native and non-native predators.
Altered hydrology	Abundance, productivity	Little Klickitat R. to L. Klickitat Falls (RM 6.38); Bowman Creek; Canyon Creek	Upstream diversions.	F, R0	Decrease in summertime base flows. Moderate impact on F, R0 in Little Klickitat from mouth to Mill Creek, Canyon and Bowman creeks	Manage diversions to maximize instream summer flows.
Reduced habitat diversity, floodplain function and channel migration processes	Abundance, productivity	Canyon Creek to RM 1.09; Little Klickitat R. to RM 1.24	Hydroconfinement. Habitat fragmentation via subdivision, land-clearing, and development.	S, F, R0, I0-1	Channel simplification and reduced riparian function. Moderate impact. Habitat protection through land acquisition/conservation easement by WDFW or land trust.	Restore floodplain and side-channel connectivity. Short-term introduction of spawning gravel. Place LWD. Protect existing habitat from future degradation.
Competition with hatchery fish	Abundance, productivity	Bowman Creek; Little Klickitat from Mill Creek to L. Klickitat Falls (RM 3.75 – RM 6.38)	Resident rainbow stocking from Goldendale Hatchery and mainstem Klickitat smolt planting (coho, steelhead).	R0, R1	Moderate impact	Change stocking practices with regards to numbers, location and timing of smolt outplanting. Research interaction with hatchery fish, native and non-native predators.

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Table II-12. Potential Limiting Factors for Middle Columbia River Steelhead in the Trout Creek MiSA (provided by Yakama Nation Fisheries Staff).

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/ Severity)	Actions
Altered sediment routing	Abundance, productivity	Trout Creek from top of falls to Bear Creek (RM 1.09 - RM2.62); Bear Creek to meadow at RM 3.10	Increased road densities and drainage extension; to a lesser degree, water withdrawal for watering roads (dust abatement).	E, I0-1	Delivery of fine sediment from upstream tributary sources. Point source delivery of fine sediment associated with road drainage. Extreme impact on E in Bear Creek from mouth to meadow at ~RM 3.1; high impact in Trout Creek from cascade to Bear Creek; moderate on I0-1 throughout	Improve road drainage characteristics and surfacing. Disconnect roads from stream. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones.
Reduced food web	Abundance, productivity	Trout Creek from top of falls to Bear Creek (RM 1.09 – RM 2.62); Bear Creek to meadow at RM 3.10	Road densities, past riparian logging.	F, R0, I0-1, R1	Elevated temperatures and fine sediment levels. High impact on F in Trout Creek from cascade to Bear Creek and in Bear Creek to ~ RM 3.1; moderate impact on R0, I0-1, R1 in Bear Creek	Restore floodplain connectivity. Improve road drainage characteristics and surfacing. Disconnect roads from stream. Re-vegetate riparian zone and floodplain. Eradicate non-native invasive plant species from critical watershed areas. Riparian forest management and planning: plan to leave buffer strips in riparian forest zones.
Degraded water quality, particularly water temperatures	Abundance, productivity, spatial structure	Trout Creek from top of falls to Bear Creek (RM 1.09 – RM 2.62);	Floodplain roads; past riparian logging.	S, E, F, R0	Reduced riparian canopy; reduced perennial and hyporheic flows. High impact on E and moderate impact on S, F, R0 in Trout Creek from cascade to Bear Creek	Restore floodplain connectivity. Re-vegetate riparian zone and floodplain.
Reduced key habitat quantity, loss of channel structure and floodplain connectivity	Abundance, productivity	Trout Creek from top of falls to Bear Creek (RM 1.09 – RM 2.62); Bear Creek to meadow at RM 3.10	Hydroconfinement; road densities, floodplain roads, past riparian logging.	F, R0, M1, PH	Channel simplification and disconnected side-channels. Reduced LWD. Moderate impact on F, R0, M1, PH in Trout Creek from cascade to Bear Creek, and on F, PH in Bear Creek to ~RM 3.1	Place LWD. Disconnect roads. Excavate pools. Augment gravel. Restore floodplain connectivity.
Reduced habitat diversity, degraded channel structure, floodplain connectivity	Abundance, productivity	Trout Creek from top of falls to Bear Creek (RM 1.09 – RM 2.62); Bear Creek to meadow at RM 3.10	Hydroconfinement.	S, F, R0	Channel incision and disconnected side-channels. Reduced LWD. Moderate impact on affected life stages in Trout Creek from cascade to Bear Creek, and in Bear Creek to ~ RM 3.1	See above.
Altered hydrology	Abundance, productivity	Trout Creek from top of falls to Bear Creek (RM 1.09 – RM 2.62); Bear Creek to meadow at RM 3.10	Channel incision related to roads; increased peak flows. Reduced perennial and hyporheic flows associated with incision and extension of the drainage network by forest	E, F, I0-1,R0	Increased peak flows; reduced perennial and hyporheic flows. Moderate impact on F, R0 in Trout Creek from cascade to Bear Creek, and in Bear Creek to ~ RM 3.1	Restore floodplain connectivity. Disconnect road drainage from stream network to decrease runoff peaks and increase retention. Restore channel morphology and overbank flow frequency…reconnect floodplains.

Limiting Factor	VSP Parameters Impacted	Sites Affected	Threats	Life Stages Affected*	Significance (Scope/ Severity)	Actions
			roads.			
Blocked or impaired passage	Abundance, spatial structure	Waterfall reach and upstream	Numerous (>10) naturally occurring cascades and waterfalls (6-8'); at least four road crossings that act as partial barriers (all four are upstream of the waterfall reach).	R0, R1, R2+, TR2+, PM	Though no one cascade is beyond the published ability of adult steelhead in terms of sheer size, there are several with very challenging hydraulics. Cumulatively, they likely restrict nearly all passage. Passage and spawning frequency of this watershed largely undocumented, assumed to be minimal above high gradient reach within lower 1.5 miles. May have been higher historically, but debris torrent associated with road failures in 1974 is believed to have radically altered channel morphology in lower five miles of Trout Creek. Passage conditions prior to torrent are unknown.	Provide passage where existing culverts block passage.

* Key to life history stage codes: S=Spawning; E=Egg incubation; F=Fry colonization; R0=0-age active rearing; I0-1=0,1-age inactive; M1=1-age migrant; R1=1-age active rearing; R2+=2+-age active rearing; M2+=2+-age active migrant; TR2+= 2+-age transient rearing; PM= pre-spawning migrant; PH= pre-spawning holding. **Bold** style denotes high to extreme impact on that life stage.

Appendix III. Current Efforts and Regulations

Numerous projects have been completed recently or have been initiated to address factors affecting salmonid production in the Klickitat subbasin. Additionally, there are numerous rules and regulations in place that will prevent or minimize future effects on salmonid production. These actions and regulations are described in the following sections.

Habitat Restoration Actions

Positive change is underway to address limiting factors and threats to improve steelhead habitat conditions. A number of actions are proposed, being planned, or are already being implemented in the subbasin to address these conditions and the affected populations.

Castile Falls Fishway

One major change is the renovation of the Castile Falls Fishway. Castile Falls, a natural barrier consisting of multiple cascades and barriers, was a historical obstruction to the upstream migration of anadromous fish into the upper Klickitat watershed. The fishway was first constructed in the early 1960s. Design flaws and improper maintenance contributed to the failure of the first attempt to provide passage over the falls. Recently, the Castile Falls Fishway was renovated to bring it into compliance with NMFS fish passage standards and facilitate anadromous fish passage to habitats in the upper subbasin. From 2003-2005, work was completed on the two fishway tunnels within the Castile Falls complex. Design improvements consisted of conversion from a pool-weir style fishway to a vertical slot fishway to allow passage over a wider range of river flow conditions and to reduce maintenance needs. Project engineers and biologists have measured improved flow, attraction flow and energy dissipation factor (EDF) within the weir—all of which are consistent with industry standards and which meet criteria for fish passage. Funds were appropriated after the major 1996 flood to perform major maintenance activities to this NOAA Fisheries/Mitchell Act-funded fishway. The first complete season that these facilities will be operational ends in 2006. At this time, a performance evaluation will be made (YN and Harbor Engineering Co. 2006).

The Castile Falls Enumeration Facility (CFEF) will provide the ability to enumerate escapement into the upper Klickitat subbasin, and assess recent improvements to the Castile Falls Fishway. A counting station will be placed in the upper CFEF. This structure will be installed at the fishway exit of the Castile Falls 10/11 Fishway tunnel and will include video monitoring and PIT-tag detection capabilities, as well as the ability to trap salmon and steelhead for biological and DNA assessment. The recounting structure will allow fisheries managers to: (1) determine escapement of Klickitat spring Chinook and summer steelhead into headwater habitats; (2) assess stock status and future trends as needed to calculate natural production and adult-to-adult return rates, and to refine EDT and run forecasting models used to guide supplementation and habitat

restoration actions and set harvest objectives; (3) conduct video monitoring to gain critical biological data such as species, run timing, size, and sex ratio of returning adults; and (4) collect age and DNA information on returning adults.

Lyle Falls Fishway

Improvements are also planned at Lyle Falls Fishway to address limited adult fish passage through the fishway into the Klickitat subbasin. Engineering assessments (Harbor Consulting Engineers, Inc. 1996) identified the following factors currently restricting passage at the fishway:

1. Inadequate attraction water
2. Location of the fishway entrance
3. Configuration of the fishway entrance ports
4. Location of the fishway exit, with fish exiting into swift water
5. Trash rack debris accumulations
6. River shoaling at the fishway exit

A subsequent HEC-RAS hydraulic model report, using fisheries criteria in accordance with the accepted design criteria approved by fishery agencies (NOAA and WDFW), outlined repairs, modifications, and retrofits that would facilitate increased passage into the Klickitat subbasin for all fish at nearly all flow conditions.

The completion of on-going engineering and design work for Lyle Falls will establish a facility that allows a high proportion of returning fish to be physically examined at a location in the lower watershed. A video monitoring and PIT-tag detection system would enable escapement monitoring, provide run-timing information, and improve enumeration of natural- and hatchery-origin recruits returning to the subbasin. It could also determine the presence/absence of a fluvial bull trout population. The collection facility would support data collection that bears on the scientific justification for particular supplementation activities proposed for the subbasin. See ISRP 2005-16. The facility would support monitoring and evaluation strategies in the proposed Klickitat Anadromous Fishery Master Plan (KMP) that can be undertaken prior to implementation of supplementation activities, including the following:

- *Strategy SC3d. Use radio telemetry, mark-recapture, and/or run reconstruction to determine passage and entrainment rates at Lyle and Castile Falls and to track natural spawners to their spawning grounds.*
- *Strategy SC5a. Collect DNA samples and morphometric data from fish passing through the Lyle Falls and Castile Falls traps. Use findings from Yakima and other Columbia Basin studies in conjunction with information from these samples to target genetic studies in the Klickitat subbasin. Convene meetings of tribal and state geneticists as necessary to further develop sampling rates, protocols, and evaluation measures.*

- *Strategy SC6b. Update and maintain all Klickitat-related databases with historical and current harvest data.*
- *Strategy SC6c. Use run reconstruction methods developed for Yakima Basin spring Chinook to reconstruct Klickitat run and harvest to the Columbia River mouth.*

Fish passage barriers

Current culvert replacement projects throughout the subbasin are ensuring that passage structures will allow movement of all life stages of salmonids by maintaining a natural stream bottom and stream width, and allowing for natural floodplain function. These bottomless arch culverts and bridges allow for the natural movement of sediments, bedload material, and large woody debris needed for the formation of pool and complex rearing habitats.

Washington State Parks recently replaced a railroad trestle that was impeding steelhead migration in Logging Camp Creek. Klickitat County, Yakama Nation Fisheries, WDFW, two private landowners, Mid-Columbia Regional Fisheries Group and community volunteers recently completed a fish passage and habitat restoration project that enables steelhead to access habitat in Snyder Creek.

Habitat enhancement projects

Habitat enhancement projects are also being implemented by a variety of different entities in many parts of the watershed to improve spawning and rearing conditions. The Underwood Conservation District, which includes some western portions of the Klickitat watershed, repaired a headcut in 2004 in upper Snyder Creek, the result of previous incision and downcutting in the headwaters, which they continue to monitor.

The Mid-Columbia Fisheries Enhancement Group is involved in a number of habitat restoration projects in the Klickitat River subbasin in conjunction with YKFP, Federal and state agencies, local partners and private landowners. In the spring of 2006, Mid-Columbia Fisheries began a riparian restoration project along 2,000 linear feet of river bank on the lower mainstem Klickitat. Mid-Columbia Fisheries was a partner in a project on the Little Klickitat River sponsored by the Central Klickitat Conservation District. This project restored a 350 ft. section of the Little Klickitat River within the Goldendale City limits. The goal of the project is to improve water quality, stabilize eroding stream banks, reduce sediment, increase riparian cover, and reduce water temperature. As part of the project, old abutments made from dilapidated barrels and other debris was removed from the river banks. Banks were re-shaped, large woody debris was installed and the area is being re-planted.

A number of habitat projects are underway to address the temperature TMDL (Anderson 2004) for the Little Klickitat. The City of Goldendale rehabilitated Bloodgood Springs which feeds Bloodgood Creek, a source of cold water for the Little Klickitat River. Bloodgood Springs has been abandoned as a city water source, and the water rights were

transferred to a well in the Simcoe Mountains.. The pumping infrastructure neat the Bloodgood stream has been removed. (David McClure, personal communication).

In 2003, the City of Goldendale abandoned its use of Bloodgood Springs at the head of Bloodgood Creek and moved its water right for these springs to a well in the Simcoe Mountains. Additionally, this well in the Simcoe Mountains has been added to the authorized points of withdrawal for the City of Goldendale's "Mountain Springs" water right. This water right change has enabled the City of Goldendale to decrease its use of the springs which are in the headwaters if the Little Klickitat River. In recent years, the City brought the "Basse Well Field" on line and reduced the City's dependence on the springs in the Little Klickitat River's headwaters. The City of Goldendale historically land applied wastewater, now the City's new wastewater treatment plan puts treated effluent directly into the Little Klickitat River, improving stream flow in the river. The City is following-up on work started under the WRIA 30/Klickitat River watershed planning effort by obtaining grant funding and implementing more intensive investigations of aquifer storage and recovery opportunities for addressing climate change/variability concerns as they relate to the City's water needs and Little Klickitat River stream flows. In support of implementing the *Klickitat River Management Watershed Plan*, the City has obtained grant funding and initiated a project to improve its water conveyance system and achieve significant water conservation objectives, which are anticipated benefit Little Klickitat River stream flows.

The Central Klickitat Conservation District also has a number of projects in progress to address water quality and/or bank stability in the Little Klickitat watershed in conjunction with the Washington Conservation Corps, the Northwest Service Academy, Klickitat County and others through EQIP (Environmental Quality Incentives Program), CREP (Conservation Reserve Enhancement Program and CCRP (Continuous Conservation Reserve Program). Additionally, TMDL implementation work (e.g., stream flow and temperature monitoring, riparian planting) by the conservation district is support by a chapter 319 grant and related conservation programs or grants.

The USDA Forest Service is working on restoring an approximately 25-acre parcel near the mouth of the Klickitat River on the west bank. The goal of the project is to re-establishing the native riparian and wetland plant communities.

The Klickitat Public Utility District (KPUD) participates in the WRIA 30/Klickitat watershed planning process which addresses water quantity, water quality, and fish habitat within the Klickitat Basin. A recent project with potential benefits to water quality involved replacing the town of Klickitat's wastewater collection system piping with interceptor tanks and new pipe to reduce the affects of storm water and flooding. KPUD replaced the wastewater treatment plant. The plant employs an ultraviolet light treatment system to provide pathogen reduction (to kill fecal coliform) and to eliminate the daily use of chlorine as the main means of germicide. This treatment method will eliminate the discharge of chlorine into the Klickitat River from the plant. These two projects received approval by members and Elders of the Yakama Nation in 2004.

Construction was completed in May of 2007 (Tim Furlong, Klickitat PUD, personal communication, 2009).

Habitat restoration activities are a key component of the Yakima/Klickitat Fisheries Project (YKFP), an effort co-managed by the Yakama Nation Fisheries Program (lead agency) and Washington Department of Fish and Wildlife aimed at recovery of native anadromous salmonid populations in the Yakima and Klickitat River basins. The principal focus of the YKFP is to increase natural production of and opportunity to harvest salmon and steelhead in the Yakima and Klickitat subbasins using supplementation, harvest augmentation and habitat improvements. The YKFP is sponsored in large part by the Bonneville Power Administration with oversight and guidance from the Northwest Power and Conservation Council (NPCC) (Yakama Nation Fisheries 2006).

The Klickitat Watershed Enhancement Project (KWEP) conducts protection and restoration projects in the Klickitat River and tributaries to subbasin supporting native anadromous fish production. The goal of the KWEP, in keeping with the objectives of the Klickitat Subbasin Plan, the Klickitat Lead Entity Strategic Plan and the 1994 NPCC Fish and Wildlife Program, is to restore watershed health to aid recovery of salmonid stocks in the Klickitat subbasin. Restoration activities are aimed at restoring stream processes by removing or mitigating watershed perturbances and improving habitat conditions and water quality. Protection activities complement restoration efforts within the subbasin by securing refugia and preventing degradation of habitat. Actions under these projects include instream large woody debris placement, culvert replacements and other passage improvements, forest road rehabilitation, floodplain reconnection, and habitat acquisition; all of these habitat actions are consistent with objectives described in the subbasin plan (NPCC 2004, pp. 333-352). Assessment, monitoring and data management are also crucial components of the KWEP Program. Cooperation with state, Federal, tribal, and private entities ensures maximum effectiveness in 90 percent of the off-reservation project area in private ownership (Conley 2006).

The *Klickitat Watershed Management Plan* was completed and approved under chapter 90.82 RCW. This watershed plan (available at http://klickitatcounty.org/NaturalR/default.asp?fD=3) will guide management of water resources in those areas of the Klickitat Basin that are outside of the Yakama Reservation and tribal trust lands. The purpose of the watershed plan is to incorporate broad-sense interests (e.g., aesthetic and recreational values, consideration of species not listed under the ESA) that eclipse the purposes of the ESA. As provided in state statute, a detailed implementation plan, *Detailed Implementation Plan Klickitat River Basin (WRIA30)* (Aspect 2008) (available at http://klickitatcounty.org/NaturalR/Content.asp?fC=23&fD=3), was developed during the first year following watershed plan approval. Primary responsibility for implementing the watershed plan is assigned to the "Implementing Governments," which are Klickitat County, state agencies (represented by the Department of Ecology), Klickitat PUD, City of Goldendale, and Central Klickitat Conservation District. Action-specific

responsibilities and terms of commitment (e.g., rules, ordinances, or agreements), funding sources, and schedules with milestones for project completion are specified in the detailed implementation plan. Grant funding for the first five years of watershed plan implementation is provided for in chapter 90.82 RCW. Actions completed pursuant to the watershed planning process have included various assessments pertaining to water quality, water quantity, and fish habitat in the Klickitat Basin, and installation and maintenance four continuous flow monitors on the Little Klickitat River and three continuous flow monitors on Swale Creek, and, installation and maintenance of a SNOTEL precipitation monitoring station in the Simcoe Mountains. Priority goals in the watershed plan include those pertaining to the following key concerns:

- Current and future water demand (which consider stream flow needs of fish);
- Summer stream flow in the Little Klickitat River;
- Little Klickitat River temperature;
- Swale Creek temperature;
- Fish habitat restoration and protection; and
- Potential effects of population growth on fish habitat.

Klickitat County is actively engaged in projects and programs benefiting ESA-listed fish species within the county. The County is the lead agency for watershed planning and *Klickitat Watershed Management Plan* implementation, as well as the lead entity for the "SRFB process" through which PCSRF and state finding is obtained for salmon and steelhead habitat projects within the Klickitat and White Salmon River basins. Over the last five years the County has sponsored approximately a dozen salmon and steelhead habitat restoration projects, conducted in cooperation with a range of partners including the EKCD, Mid-Columbia Regional Fisheries Enhancement Group, Yakama Nation Fisheries, and WDFW. The County has also contributed matching funds for such projects as the Klickitat Wastewater Treatment Plan upgrade and "in-kind match" for such projects as the conservation district's implementation of the Little Klickitat River Temperature TMDL.

Regulatory Protection

Various state, tribal and county regulatory mechanisms are in place to protect riparian areas from current and future threats posed to listed species through habitat loss and degradation caused by human land uses and development. Numerous voluntary programs are also available to address habitat conservation. In addition, some areas receive special protection through designation, such as Wild and Scenic River reaches, primitive areas, and wildlife refuges.

NOAA Fisheries and/or U.S. Fish and Wildlife Section 7 Consultations

Section 7 of the Endangered Species Act directs all Federal action agencies to consult with NOAA Fisheries and the U.S. Fish and Wildlife Service to ensure that their actions will not jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. Actions include not only direct Federal actions, but also actions funded with Federal dollars. A Biological Assessment or Biological Evaluation is usually developed and submitted to NMFS for review prior to implementation of the project. The reader can find additional information regarding the consultation process at: www.cit.noaa.gov/nosign/default.asp?action=ConsultationGuide.

Clean Water Act

The Federal Clean Water Act addresses the development and implementation of water quality standards, the development of total maximum daily loads (TMDL), filling of wetlands, point source permitting, the regulation of stormwater, and other provisions related to protection of U.S. waters. The Clean Water Act is administered in the State of Washington by the Department of Ecology (Ecology) with oversight by the EPA. State water quality standards are set to protect beneficial uses, which include several categories of salmonid use. Ecology has a water quality certification program under which it reviews projects that will discharge dredged or fill materials into waters of the U.S. and issues certifications that the proposed action meets State water quality standards and other aquatic protection regulations, if appropriate. Ecology also issues National Pollution Discharge Elimination System (NPDES) permits, and develops water quality cleanup plans (TMDL) to address water quality limited streams.

National Environmental Policy Act (NEPA) Review

NEPA requires Federal agencies to consider the probable impacts of their proposed activities, programs, and projects (including funding of state, local, and private actions) on the quality of the human environment. NEPA reviews help agencies decide whether to undertake a proposed action. In most cases, the NEPA review requires the development of an Environmental Assessment (EA) or Environmental Impact Statement (EIS) that addresses the probable effects of a project and its alternatives on various elements of the environment, including soils, geology, landscapes, atmospheric conditions, vegetation, fish and wildlife, and cultural resources. Many Federal funding programs are covered under a general NEPA review completed when the funding program was developed.

Watershed Planning Act

In 1998 chapter 90.82 RCW was amended with the passage of ESHB 2514. This law is also known as the Watershed Planning Act. The Watershed Planning Act was established to address the diminishing water availability and quality, and the loss of habitat for fish in the State of Washington. The Watershed Planning Act provides a framework for local citizens, tribes, and state and local agencies to work together to develop and implement Watershed Management Plans for entire watersheds.

As part of the planning process, a watershed assessment is completed for each Water Resource Inventory Area (WRIA) to evaluate water supply and use. Once the watershed assessment is complete, a management plan, followed by a detailed implementation plan, is developed to address water quantity, water quality, and fish habitat issues identified in the assessment. A watershed assessment has been completed for the Klickitat subbasin (WRIA 30) (WPN and Aspect 2005a) and the *Klickitat River Watershed Management Plan* (WPN and Aspect 2005a) and *Detailed Implementation Plan Klickitat River Basin (WRIA30)* (Aspect 2008) have been approved.

State Environmental Policy Act (SEPA)

SEPA regulations require an environmental review of actions taken by the state and local agencies, including funding and permitting. Some actions, such as the construction of single-family dwellings, minor road repair, and issuance of business licenses, are exempt. A SEPA review evaluates the probable environmental effects of a proposed project. This information is used to determine if the action should be taken as proposed, if mitigation is necessary, or if the proposal should be rejected.

Forest & Fish Regulations (Washington State)

The Washington Forests & Fish Law (ESHB 2091) was signed into law in 1999 as part of The Washington State Forest Practices Act (Title 76.09 RCW), passed in 1974. The Forests & Fish Law, based on the Forests & Fish Report, resulted in changes to forest practices rules to protect riparian and aquatic resources on more than eight million acres of private forestland. It is intended to meet the provisions of the Federal Clean Water Act concerning non-point source silvicultural practices. Changes to the law included:

- Updates of the stream typing system in the state to improve mapping of fish-bearing waters,
- Increases in buffer widths along fish bearing and non-fish bearing streams,
- Changes in forest practices to protect against landslides
- Mandatory requirements to update the forest road system to hydrologically disconnect roads from streams and minimize sediment delivered to streams,
- New regulations on pesticide applications to prevent or avoid drift of chemicals into streams,
- Increased protection of wetlands
- Changes in enforcement,
- Establishment of a scientifically based adaptive management and monitoring process for evaluating the impact of forest practices on aquatic resources,
- Establishment of a process for amending the forest practices rules to incorporate new information as it becomes available, and
- Establishment of a small landowner office to assist non-industrial landowners.

Additional information regarding the Forest Practices rules can be found at: http://www.dnr.wa.gov/forestpractices.

- The Washington Department of Natural Resources, on behalf of the State of Washington, submitted applications to NMFS and the U.S. Fish and Wildlife Service for incidental take permits under section 10 of the Endangered Species Act. Issuance of these permits would provide assurances that all forest practices activities in compliance with the state forest practices rules and administrative program will satisfy ESA requirements for aquatic species. The two services released the final HCP, the final environmental impact statement (FEIS), and implementing agreement in a ***Federal Register*** *Notice* on Jan. 27, 2006. This notice provides an opportunity for the public to review the final documents and the responses to public comments on the draft documents.

Klickitat County Shorelines Master Plan

In 1971 the Washington State Legislature passed the Washington Shoreline Management Act (SMA), adopted by public referendum in 1972. The purpose of the Act is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines" by requiring every county and many cities to develop a Shoreline Master Plan to govern development in shoreline areas http://www.ecy.wa.gov/programs/sea/sma/st_guide/intro.html). Klickitat County's Shorelines Master Plan (SMP) was first adopted in 1975 and has been updated periodically since then. The SMP and brochure on the shorelines permit program can be accessed from the Klickitat County Planning Department's web site: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788.

The Klickitat County's (SMP) regulates "development" within the "shorelines" of the Klickitat River and other water bodies in Klickitat County's jurisdiction. "Development" is broadly defined as: construction or exterior alteration of existing structures; dredging; drilling; dumping; filling; removal of any sand, gravel or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to the SMP regulations at any state of water level. "Shorelines" are those lands extending landward for 200 feet in all directions as measured from the ordinary high water mark, floodways and contiguous floodplain areas landward 200 feet from such floodways;, and all wetlands and river deltas associated with the streams and lakes. The SMP applies to the shorelines of the main stem of the Klickitat River as well as the shorelines of all tributaries with a mean annual flow of 20 cfs or more.

The SMP designates various shorelines of the Klickitat River and its tributaries as "environments", which determine the level of protection that is warranted. Much of the Klickitat River is designated either "Natural Environment" which prohibits most development within its shorelines or "Conservancy Environment", which allows a limited scope of development, subject to conditions (i.e. shoreline conditional use permit).

Each development proposal is subject to review pursuant to the shoreline environment within which it is to be located. One or more shoreline permits must be secured prior to implementation: Substantial Development Permits (SDP) are required for any

development for which the total cost or fair market value exceeds $5,000, or any development which materially interferes with the normal public use of the water or shorelines; Shoreline Conditional Use Permits (CUP) are required for development types that warrant conditions to ensure consistency with the SMP; and Variances (VAR) are issued to grant relief from specific bulk, dimensional, or performance standards of the SMP in order to avoid unnecessary hardship, provided that extraordinary circumstances are shown to exist and the public interest shall suffer no substantial detrimental effect. Some types of development, such as a single-family residence, normal maintenance and repair, or construction of a normal protective bulkhead for a single family residence, are exempt from the requirement of a substantial development permit, but are still subject to all other provisions of the SMP.

Existing structures and developments that were established prior to adoption of the SMP are considered legally established "non-conforming" uses. Since adoption of the SMP, all developments within shorelines, including modifications to non-conforming uses, have been reviewed by the County and Washington Department of Ecology (Ecology) to ensure compliance with the goals and requirements of the SMP.

The Department of Ecology reviews the County's permit decisions and has final authority to approve or deny conditional use permits and variances. Persons may appeal the final decision to the Shorelines Hearings Board.

Klickitat County Critical Areas Ordinance

Klickitat County adopted a Critical Areas Ordinance (CAO) in 2001 and, with the concurrence of Washington Departments of Fish and Wildlife, Community Trade and Economic Development, and Ecology, amended it in 2004. The CAO extends beyond the geographical scope of the County's SMP to protect wetlands, critical fish/wildlife habitat, geologically hazardous areas, aquifer recharge areas, and frequently flooded areas. The CAO is, in effect, an overlay on existing land use regulations. The CAO provides for standard setbacks of 300' from Category I wetlands; 200' from Category II; and 75' from Category III and IV. The CAO provides for standard buffers of 200' from Type 1 & 2 waters; 150' from Type 3 waters; 50' from Type 4 waters; and 25' from Type 5 waters. A wildlife habitat management plan is required for new development that will likely impair habitat functions and values. As with the SMP, developments and uses that existed prior to the adoption of the CAO are considered legally established "non-conforming" uses. The CAO and brochures land use permit programs can be accessed from the Klickitat County Planning Department's web site: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788.

Klickitat County Floodplain Management Ordinance

The Klickitat County Floodplain Management Ordinance (FPO) regulates all development and activities that may increase flood hazards. A permit is required for development within areas of special flood hazard (with at least one percent chance of flooding). The applicant for a non-residential structure must include a certification and

flood analysis conducted by a professional engineer. In general, development that will does not meet the specific criteria in the ordinance for development in these areas, to protect public health and safety, will be denied. The FPO and brochures land use permit programs can be accessed from the Klickitat County Planning Department's web site: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788.

Klickitat County Zoning Ordinance

The Klickitat County Zoning Ordinance (CZO) was adopted in 1979 and has been amended over time. Much of the Klickitat River watershed is zoned by the CZO as "extensive agriculture" which requires a 20-acre minimum lot size for the purpose of dividing properties, and new development/uses are restricted to resource management uses/activities and other compatible uses. One permanent residential dwelling is allowed per lot. Some areas of the watershed are zoned for residential development. The allowable minimum lot size for new lots is either 1 or 2 acres; and one residential dwelling is allowed per lot. Other than residential development, most new development/uses in these zones is either prohibited or allowed per a zoning conditional use permit. The CZO and brochures land use permit programs can be accessed from the Klickitat County Planning Department's web site: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788.

Klickitat County Environmental Ordinance (CEO)

The Klickitat County Environmental Ordinance (CEO) was adopted pursuant to the State Environmental Policy Act (SEPA). The CEO and SEPA require an analysis of probable significant adverse environmental impacts that may result from a proposed development. The CEO and SEPA require a threshold determination for each proposed development that is not exempt. The threshold determination is a determination that a project will or will not have probable significant adverse environmental impacts. If a project has probable significant adverse impacts, and environmental impact statement (EIS) is prepared. Any proposed development/use that is not specifically exempt in SEPA, chapter 43.21C RCW, or the SEPA rules adopted by the Department of Ecology, chapter 197-11 WAC, is required to comply with SEPA. Klickitat County provides applicable state agencies and tribes, as well as the public, the opportunity to review threshold determinations and EISs.

Washington State Water Pollution Control Act (Chapter 90.48 RCW)

This act gives Ecology the authority to protect water quality in the state and to promulgate regulations as needed to achieve this goal. The Act makes discharges of pollutants into waters of the state unlawful and has provisions for enforcement of violations, including the authority and process for issuing compliance orders and civil penalties, and for seeking criminal penalties. The Act also provides for permitting processes, cooperation with other entities, water quality monitoring, grants, and numerous other subjects regarding management of water quality issues in the state.

Washington's statewide monitoring program

In 2001, Substitute Senate Bill (SSB) 5637 was signed into law. This act related to monitoring of watershed health and salmon recovery. The Monitoring Oversight Committee developed a comprehensive statewide strategy that addresses the actions identified in SSB 5637 (WPN and Aspect Consulting 2005). Among other things, the Plan is intended to provide information regarding trends in fish, water, and habitat conditions and assess effectiveness of actions taken to improve watershed health and provide for salmon recovery. The strategy includes documentation of fish population trends in some areas of the state; however, the Klickitat River watershed is not one of the areas included to date in that monitoring effort. The strategy is also monitoring the effectiveness of habitat restoration efforts funded by the state. The monitoring of project effectiveness follows the Monitoring and Evaluation Strategy (Washington Salmon Recovery Funding Board 2003) that was developed in support of the Comprehensive Statewide Strategy. The Monitoring and Evaluation Strategy specified methods to assess a wide range of restoration and protection projects.

On-Site Sewage Systems

Chapter 246-272 of the Washington Administrative Code (WAC) regulates the on site disposal of sewage in the state. The law is applicable to septic systems as well as larger on-site systems. The rule addresses location of systems, site evaluations, design, installation, inspection, operation and maintenance, repair, abandonment, and other areas of concern. The rule helps to prevent the discharge of sewage into fish-bearing streams.

Hydraulic Code

Chapter 75.20 RCW governs construction projects within the waters of the state. The law requires hydraulic project approvals from the Department of Fish and Wildlife for wharves, bulkheads, bridges, culverts, fish habitat restoration projects, and other construction activities within the ordinary high water mark. This regulation helps to protect fish and fish habitat during construction.

Regulation of Dairy Farms

Chapter 90.64 RCW, the Dairy Nutrient Management Act, includes a number of requirements designed to protect water quality from dairy operations. These are in addition to NPDES requirements in the Federal and state Clear Water Acts for concentrated animal feeding operations. The Act requires inspection of all dairy farms, implementation of dairy nutrient management plans, technical assistance and enforcement (including civil penalties) against significant polluters. The intent of the regulation is to protect water quality and, subsequently, fish habitat. Ecology is the primary regulatory authority under this Act.

Other Rules and Regulations

There are over 100 additional rules and regulations applicable to the protection of water quality and fish habitat in the State of Washington. These rules cover a broad range of

subjects such as groundwater quality standards, application of pesticides, well construction, motor oil disposal, utilities, solid waste disposal and recycling, water supply facilities, mining, energy facilities, dikes and levees, aquiculture, etcetera. Lists of applicable laws and rules and links to the specific requirements of those laws and rules can be found at: www.ecy.wa.gov/laws-rules.

Yakama Reservation Forest Management Plan

The Yakama Nation has a variety of protective land use regulations in effect on reservation lands. One of these is the Forest Management Plan (FMP). Under the 1993-2002 FMP, the Yakama Administrative Forest was divided into 11 Land Use Management Areas (LUMA). Each LUMA was managed for multiple uses with emphasis on dominant resource features and objectives. The draft FMP soon to be ratified changes the designation of LUMAs to Management Emphasis Areas (MEA), which will be managed within the forest habitat types (USDI Bureau of Indian Affairs and Yakama Indian Nation 2004). The forestry program is using historical species composition and stand densities as references for the desired future stand conditions. Just as with the health of aquatic systems, forest health describes the ability of a forest ecosystem to remain productive, to maintain a diversity of plants and animals, aesthetic appeal, and resource sustainability, and to withstand disturbances over time. In addition, a healthy forest is resilient to periodic disturbances such as drought, insects, diseases, fires, climatic change, and management practices.

The Forest Management Plan prescribes the number of miles and density of roads allowed to be built for the purpose of harvesting timber from the Administrative Forest, and forest treatments such as thinning and prescribed burns are being put into place to move the forest vegetation more toward the historical condition of seral stands rather than dense, late successional forest cover. Streams are classified according to their flow, use for domestic purposes and use by fish for spawning, rearing and migration, and buffers and harvest restrictions are set accordingly. The objectives are the preservation of stream bank and riparian cover, water quality and flow maintenance and soil stabilization (USDI Bureau of Indian Affairs and Yakama Indian Nation 1993).

The draft Yakama Nation Forest Management Plan (FMP) designates Management Emphasis Areas that provide for special management emphasis within the closed area (closed to non-tribal members) of the reservation. Table III-1 lists the Management Emphasis Areas within the Klickitat subbasin, as well as the acreage and goal of each.

Table III-1. Trust Forest and Non-Forest Areas by Management Emphasis (BIA and YN 2004).

Management Emphasis Area	Forest (Acres)	Non-Forest (Acres)	Total (Acres)
General Forest	228,623	11,697	240,320
Wildlife Winter Habitat	99,684	52,131	151,815
Safety Corridor	7,086	523	7,609
Old-Growth	14,485	0	14,485
Canyon	50,500	11,749	62,249
Alpine	41,035	7,062	48,097
Riparian	10,403	628	11,031
Primitive	30,990	5,197	36,187
Tract D Recreation	10,072	6,794	16,866
Traditional Use	1,934	407	2,341
Total Acres	**494,812**	**96,188**	**591,000**

Court-mandated buffers on salmon-supporting waters

In January 2004, the U.S. District Court for the Western District of Washington at Seattle ordered protections to prevent the potential adverse effects of any of 54 pesticides on threatened and endangered salmonids. Under the order, buffer zones are required for the application of any of the 54 pesticides that received a "likely to adversely affect" determination as a result of EPA review. The order prohibits ground applications of these pesticides within 20 yards (60 feet) of streams and other water bodies accessible to salmon. The order also requires a buffer zone of 100 yards (300 feet) for aerial applications. The buffer zones remain in effect until the conclusion of the EPA consultations with NMFS. The U.S. Court of Appeals for the Ninth Circuit upheld the January 2004 order in June 2005. The no-spray buffers will remain in effect until EPA and NMFS complete the pesticide consultation process (WSDA 2006). Streams in the Klickitat subbasin that are subject to these buffers are: Blockhouse Creek, Butler Creek, East Prong and West Prong Little Klickitat River, mainstem Klickitat River, Little Klickitat River, Snyder Creek, Swale Creek, and White Creek (WSDA 2006).

Conservation Reserve Enhancement Program (CREP)

The Conservation Reserve Enhancement Program (CREP) is a joint partnership between the State of Washington and USDA, and is administered by the Washington State Conservation Commission and the Farm Services Agency (FSA). The agreement was signed in 1998 and provides incentives to restore and improve salmon and steelhead habitat on private land.

The land enrolled in CREP by voluntary landowners is removed from production and grazing under 10 or 15-year contracts. In return, landowners plant trees and shrubs to stabilize the stream bank and to provide a number of additional ecological functions. Landowners receive annual rent, incentive and maintenance payments and cost share for practice installations. These payments made by FSA and the Conservation Commission, can result in no cost to the landowner for participation (http://crep.scc.wa.gov/).

Special Land Use Areas

Yakama Reservation Primitive Area

The Primitive Area, established by Tribal Council Resolution, consists of the upper reaches of the Klickitat River, roughly half of which drains into the West Fork of the Klickitat, with the other half draining directly into the Klickitat. The 1993–2002 FMP stated that the Primitive Area was to be maintained in its natural state and that natural ecological events should be allowed to occur as freely as possible, provided adjacent lands are not unreasonably affected. The Primitive Area runs from just north of Potato Hill through the Two Lakes, Howard Lake, and Fish Lake areas, then north of Jennie's Butte, through McCormick Meadows, and ending just east of Diamond Butte. The Cascade crest forms the western edge of the Primitive Area, including Cispus Pass. Much of the Forest Service land north and west of the Primitive Area is also managed as reserve, notably the Goat Rocks Wilderness.

Columbia River Gorge National Scenic Area

"The National Scenic Area was created to protect and enhance the scenic, natural, cultural and recreational resources of the Columbia River Gorge while encouraging economic development" (www.fs.fed.us/r6/columbia/). Part of the NSA has been designated along the southernmost portion of the Klickitat subbasin, adjacent to the Columbia River. All new development and land uses must be reviewed in the National Scenic Area to determine if they are consistent with the Act and the implementing land-use ordinances. The development guidelines of the management plan are implemented through land-use ordinances which must be consistent with the management plan.

Klickitat Wildlife Area

The Klickitat Wildlife Area is owned and managed by WDFW. The area covers approximately 14,000 acres in the western portion of Klickitat County. It lies on the east slope of the Cascade Mountains about halfway between the Columbia River Gorge to the south and Mt. Adams to the north. The Klickitat River forms a deep, twisting canyon on its way south to the Columbia River. This twisting characteristic has created juxtaposing areas of forage on south slopes and thermal cover on north slopes. General vegetation types include the forest riparian zone along the Klickitat River, south-facing hillsides of open grasslands, north-facing hillsides forested with conifers, and the flatter plateau covered by mixed forests of oak and pine interspersed with small grassland (http://www.wdfw.wa.gov/lands/r5klick.htm).

Conboy Lake National Wildlife Refuge

The Conboy Lake National Wildlife Refuge (NWR) is managed by USFWS. The refuge is located approximately 10 miles east of Trout Lake and 7 miles southwest of Glenwood, in the Glenwood Valley/Camas Prairie area. The NWR contains 5,184 acres of marsh, meadows, grasslands, and forest. The former mountain lake is now present only in winter and early spring. The area provides a spring migration area for Canada geese and

ducks, (mainly mallards and pintails) and wintering use for tundra swans, Canada geese, ducks, and bald eagles. Additionally, one of three known nesting areas for sandhill cranes in Washington is located on the NWR, as is one of two known populations of Oregon spotted frogs (www.r1.fws.gov/visitor/washington.html).

Wild and Scenic Rivers

The Wild and Scenic Rivers Act was created by Congress to preserve in a free-flowing condition selected rivers of the nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historical, cultural, or other similar values. On November 17, 1986, the lower 11.1 miles of the Klickitat River (from its confluence with Wheeler Creek, near the town of Pitt, to its confluence with the Columbia River) were designated as a National Recreation River under this legislation. The "recreational" designation is for those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past. The segment is administered by the Secretary of Agriculture (Wild and Scenic Rivers Act. http://www.nps.gov/rivers/wsract.html). The Act restricts the construction of any dam or other water resource project on or directly affecting a designated river, or that which would have a direct and adverse effect on the values for which such a river was established, such as its free-flowing nature. The Act directed the Forest Service to develop management plans for these portions. In addition, the Act calls for completion of Wild and Scenic River Suitability Studies on other segments of the Klickitat. The Wild and Scenic Rivers Act on the Klickitat River does not supersede local Shoreline Management Plans.

Appendix IV. Estimates of Abundance Provided by Yakama Nation Fisheries

The following information is provided by Yakama Nation Fisheries. The information contained in this appendix represents the best available information prior to the installation of the adult fishway trap near Lyle. Monitoring of adult passage through the Lyle Fishway trap is provided better estimates of population size in 2005 and 2006 (Gray 2007) and will continue to provide better estimates of population size in the future.

Prior to the run year of 2005-06, total abundance and escapement estimates of wild Klickitat steelhead are highly uncertain. Run reconstruction and escapement has relied upon estimated number of spawners expanded from redd surveys. In some years, High flow and turbidity have precluded survey ability and effectiveness resulting in low and/or conservative spawner escapement estimates. Beginning in 2005-06, a Mark-recapture procedure used for population estimates has been implemented for estimating abundance at the mouth of the Klickitat for both wild and hatchery steelhead.

In the most recent ten years between 1997-98 and 2006-07, tribal harvest of wild steelhead in the Klickitat has ranged from 0 to 363 with an average of 107 fish annually (Table 1). Estimated harvest rates derived for years prior to 2005-06 are likely biased high as result of underestimated spawner escapement and total run size to the mouth of the Klickitat. For the return years of 2005-06 and 2006-07, estimated harvest rates on wild steelhead were 5.8 percent and 3.5 percent respectively (Table 1). Expansion of the spawner escapement estimates for harvest prior to these two years would suggest a much higher rate upward around 15 percent for the period of record of 1986-2007. Considering the recent two year average of 4.7 percent expanded from the mark recapture abundance estimates, actual harvest over the recent ten year period of record has probably ranged from 3.5 percent – 10 percent of the wild run to the mouth of the Klickitat.

Table IV-1. Estimated Klickitat River Steelhead Returns, Harvest and Escapement (Source Yakama Nation Fisheries).

Klickitat River Steelhead

		Sport			Tribal						
Year	Run[1]	Hatchery	Wild	Total	Hatchery[2]	Wild[2]	Total	Escapement[3]	Redds[4]	Wild run to mouth[7]	Wild Harvest rate[8]
1986-87	9,834	1,426	54	1,480	5,107	901	6,008	2,346			
1987-88	3,751	1,480	34	1,514	1,141	201	1,342	895			
1988-89	4,208	1,718	0	1,718	1,263	223	1,486	1,004			
1989-90	1,702	833	0	833	536	95	631	238	95		
1990-91	2,957	1,055	0	1,055	1,464	258	1,722	180	72		
1991-92	3,595	823	8	831	1,620	286	1,906	858			
1992-93	3,251	1,260	0	1,260	1,033	182	1,215	776			
1993-94	3,402	1,211	25	1,236	1,151	203	1,354	812			
1994-95	1,915	857	34	891	482	85	567	457			
1995-96	1,805	864	9	873	433	76	509	423	169		
1996-97	1,082	608	14	622	241	43	284	176	71		
1997-98	2,185	1,062	18	1,080	455	80	535	570	228		
1998-99	1,521	650	12	662	224	39	263	596	239		
1999-00	1,725	575	28	603	214	0	214	908	363		
2000-01	2,851	1,433	59	1,492	495	67	562	797	319		
2001-02	5,264	3,708	16	3,724	724	55	779	761	304		
2002-03	6,022	3,552	97	3,649	1285	363	1,648	725	290		
2003-04[5]	2,766	1,673	0	1,673	369	151	520	573	229		
2004-05	2,957	1,658	0	1,658	747	153	900	399	160		
2005-06[6]		1,115	0	1,115	368	98	466	520	12	1675	5.8%
2006-07[6]						61			74	1730	3.5%
Avg:	3,305	1,378	20	1,398	968	178	1,146	701	188	1,702	4.7%

Note: Data for this table are from YN and WDFW databases and US v. Oregon TAC reports
[1]Sum of harvest and escapement
[2]Hatchery and wild proportions of tribal harvest are estimated as follows: For 1999-00 through 2005-06 percentages estimated from sampling of ceremonial and subsistence harvest were applied to total tribal harvest. For 1986-87 through 1998-99 the average percentages from the 1999-2005 sampling were applied to total tribal harvest.
[3]Assumes 2.5 fish per redd. For years when redd counts were unavailable or unreliable, assumes average escapement-to-total-harvest ratio from years when reasonably accurate redd counts were available
[4]Actual redd counts expanded for mileage surveyed
[5]Sport Harvest numbers include data from May 1 - April 30 except for 2003-04, which does not include April data
[6]High flows and turbidity limited survey ability and effectiveness, probably biasing the redd count low.
[7]Wild run to mouth includes Lyle Falls Mark-recapture expansions and tribal fisheries below Falls
[8] Estimated terminal harvest rate for wild steelhead

Recovery Plan for the Rock Creek Population of the Middle Columbia River Steelhead Distinct Population Segment

October 2009

Prepared by
National Marine Fisheries Service
Northwest Region

DISCLAIMER

Endangered Species Act (ESA) recovery plans delineate reasonable actions which the best available information indicates are necessary for the conservation and survival of listed species. Plans are published by the National Marine Fisheries Service (NMFS), usually with the assistance of recovery teams, state agencies, local governments, salmon recovery boards, non-governmental organizations, interested citizens of the affected area, contractors, and others. ESA recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than NMFS. They represent the official position of NMFS only after they have been signed by the Northwest Regional Administrator. ESA recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions.

With respect to the Middle Columbia Steelhead Recovery Plan, where areas of disagreement arose between a management unit plan and the species level, distinct population segment (DPS) plan, NMFS worked with the relevant parties to resolve the differences and in a few cases, identified in the DPS plan, decided not to incorporate the disputed material into the DPS plan.

ESA recovery plans provide important context for NMFS's determinations pursuant to section 7(a)(2) of the Endangered Species Act. However, recovery plans do not place any additional legal burden on NMFS or the action agency when determining whether an action would jeopardize the continued existence of a listed species or adversely modify critical habitat. The procedures for the section 7 consultation process are described in 50 CFR 402 and are applicable regardless of whether or not the actions are described in a recovery plan.

Contents

Acronyms and Abbreviations vii
Executive Summary viii
1. Introduction 1
1.1 Purpose of Plan 2
1.1.1 ESA Requirements 2
1.1.2 Coordination with Others 3
1.2 Context of Plan Development 5
1.2.1 Technical Recovery Teams 5
1.2.2 Planning Forums 5
1.3 How NMFS Intends to Use this Plan 7
2. Biological Background 9
2.1 Physical Setting 9
2.1.1 Topography 11
2.1.2 Hydrology 12
2.1.3 Water Quality 16
2.2 Life History Characteristics 18
2.3 Major Spawning Area 21
2.4 Salmonid Biological Structure 22
2.4.1 Distinct Population Segments 23
2.4.2 Major Population Groups 23
2.4.3 Independent Populations 24
2.5 Middle Columbia Steelhead Populations and MPGs 24
3. Recovery Goals and Delisting Criteria 27
3.1 Recovery Goals 27
3.2 Biological Viability Criteria 28
3.2.1 DPS and MPG Viability Criteria 29
3.2.2 Application of Biological Viability Criteria to Rock Creek Population 30
3.3 Threats Criteria 31
4. Current Status Assessment 36
4.1 Abundance and Productivity 36
4.2 Spatial Structure and Diversity 36
4.3 Overall Risk Rating 37
5. Limiting Factors and Threats 38
5.1 Freshwater Habitat 38
5.2 Hatchery Effects 43
5.3 Tributary Harvest 43
5.4 Out-of-Subbasin Limiting Factors and Threats 45
5.4.1 Harvest 45

5.4.2 Columbia River Hydropower Operations 46
5.4.3 Ocean Conditions 47
5.4.4 Climate Change 47
5.4.5 Other Large-Scale Threats 48
6. Recovery Strategy and Actions 49
6.1 Strategies and Actions 49
6.1.1 Gather Information on VSP Parameters 49
6.1.2 Protect and Conserve Existing Good Quality Habitat 50
6.1.3 Restore and Enhance Habitat and Gather Information 50
6.1.4 Review and Reduce Effects of Harvest 51
6.1.5 Research Effects of Hatchery Fish (If Any) 52
6.1.6 Address Out-of-subbasin Limiting Factors 52
6.2 Summary of Recovery Strategy 52
7. Implementation and Cost Estimates 57
7.1 Implementation 57
7.2 Costs 58
8. Monitoring, Research, and Adaptive Management 63
8.1 Adaptive Management 63
8.2 Designing a Monitoring and Evaluation Program to Support Adaptive Management 66
8.2.1 Implementation and Compliance Monitoring 67
8.2.2 Status and Trend Monitoring 67
8.2.3 Effectiveness Monitoring 68
8.3 Research and Critical Uncertainties 68
8.3.1 Out-of-Subbasin Uncertainties 68
8.3.2 In-Subbasin Uncertainties 69
8.4 Existing Monitoring and Research 70
8.5 Additional Needs 70
8.6 Data Management 70
8.7 Consistency with Other Monitoring Programs 71
8.8 Coordination 71
8.9 Evaluation Schedule 72
9. References 73
Appendix I. Eastern Tributaries in the Washington Gorge Management Unit 79
Appendix II. Current Efforts to Improve the Watershed 92

Figures

Figure ES-1 Rock Creek Subbasin. ix
Figure ES-2 Columbia Basin Recovery Domains for NMFS Northwest Region..... x
Figure ES-3 Middle Columbia River Steelhead Populations and Major Population Groups. xiii
Figure 1-1 Rock Creek Subbasin 1
Figure 1-2 NMFS Management Units for the Middle Columbia Steelhead DPS..... 7
Figure 2-1 Geology and Stream Location of Rock Creek Subbasin..... 9
Figure 2-2 Land Use in the Rock Creek Subbasin. 11
Figure 2-3 Stream flow, water temperature, and air temperature at the Washington Department of Ecology gage near the mouth of the Rock Creek. 14
Figure 2-4 Discharge Hydrograph from Historical USGS flow gage near mouth of Rock Creek..... 15
Figure 2-5 Monthly Exceedance Flows for Historical USGS Flow Gage near Mouth of Rock Creek. 15
Figure 2-6 Daily maximum water temperature at four stations in Rock Creek..... 17
Figure 2-7 Rock Creek subbasin major streams and steelhead distribution. 21
Figure 2-8 Rock Creek summer steelhead population boundary and major and minor spawning areas..... 22
Figure 2-9 Hierarchical levels of salmonid species structure as defined by the TRTs for ESU/DPS recovery planning. 24
Figure 2-10 Middle Columbia River Steelhead Independent Populations and Major Population Groups 25
Figure 4-1 Integrated Risk Rating for the Rock Creek Steelhead Population. 37
Figure 8-1 NMFS Listing Status Decision Framework. 65
Figure ApI-1 NMFS Management Units for the Middle Columbia Steelhead DPS 80
Figure ApI-2 NMFS Populations and Major Population Groups for the Middle Columbia River Steelhead DPS..... 82

Tables

Table ES-1 Recovery Strategy and Actions for the Rock Creek Population of Middle Columbia Steelhead. xxv
Table 2-1 Rock Creek Summer Steelhead Basin Statistics..... 26
Table 4-1 Rock Creek Summer Steelhead Population Spatial Structure and Diversity Risk Rating Summary..... 37
Table 6-1 Recovery Strategy and Actions for the Rock Creek Population of Middle Columbia Steelhead. 53
Table 7-1 Costs Associated with Proposed Reach-Specific Actions for Rock Creek Provided by Yakama Nation Fisheries. 59

Recovery Planning Glossary

abundance: In the context of salmon recovery, unless otherwise qualified, abundance refers to the number of adult fish returning to spawn.

adaptive management: Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.

anadromous fish: Species that are hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.

baseline monitoring: In the context of recovery planning, baseline monitoring is done before implementation, in order to establish historical and/or current conditions against which progress (or lack of progress) can be measured.

biogeographical region: an area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms (in this case, salmonids) have evolved in common.

broad-sense recovery goals: Goals defined in the recovery planning process, generally by local recovery planning groups, that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values.

compliance monitoring: Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.

delisting criteria: Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a NMFS determination and may include both technical and policy considerations.

distinct population segment (DPS): A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NMFS policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.

diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in

freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.

endangered species: A species in danger of extinction throughout all or a significant portion of its range.

effectiveness monitoring: Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?

ESA recovery plan: A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.

evolutionarily significant unit (ESU): A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species.

extinct: No longer in existence. No individuals of this species can be found.

extirpated: Locally extinct. Other populations of this species exist elsewhere. The ICTRT considers extirpated steelhead populations to be those that are entirely cut off from anadromy, such as the Crooked River population. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

factors for decline: Five general categories of causes for decline of a species, listed in the Endangered Species Act section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.

functionally extirpated: Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population.

hyporheic zone: Area of saturated gravel and other sediment beneath and beside streams and rivers where groundwater and surface water mix.

implementation monitoring: Monitoring to determine whether an activity was performed and/or completed as planned.

independent population: Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.

indicator: A variable used to forecast the value or change in the value of another variable.

interim regional recovery plan: A recovery plan that is intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.

intrinsic potential: The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

intrinsic productivity: The expected ratio of natural-origin offspring to parent spawners at levels of abundance below carrying capacity.

kelts: Steelhead that are returning to the ocean after spawning and have the potential to spawn again in subsequent years (unlike most salmon, steelhead do not necessarily die shortly after spawning).

large woody debris (LWD): A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.

legacy effects: Impacts from past activities that continue to affect a stream or watershed in the present day.

limiting factor: Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status.

locally developed recovery plan: A plan developed by state, tribal, regional, or local planning entities to address recovery of a species. These plans are being developed by a number of entities throughout the region to address ESA as well as state, tribal, and local mandates and recovery needs.

maintained status: Population status in which the population does not meet the criteria for a viable population but does support ecological functions and preserve options for ESU/DPS recovery.

major population group (MPG): A group of salmonid populations that are geographically and genetically cohesive. The MPG is a level of organization between demographically independent populations and the ESU or DPS.

management unit: A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.

metrics: A metric is something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.

morphology: The form and structure of an organism, with special emphasis on external features.

natural-origin fish: Fish that were spawned and reared in the wild, regardless of parental origin.

parr: The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.

phenotype: Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties, or behavior.

piscivorous: (Adj.) Describes fish that eat other fish.

productivity: The average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

recovery domain: An administrative unit for recovery planning defined by NMFS based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.

recovery goals: Goals incorporated into a locally developed recovery plan, which may include delisting (i.e. no longer considered endangered or threatened), reclassification (e.g., from endangered to threatened), and/or other goals. Broad-sense goals are a subset of recovery goals (see glossary entry above).

recovery plan supplement: A NMFS supplement to a locally developed recovery plan that describes how the plan addresses ESA requirements for recovery plans. The supplement also proposes ESA delisting criteria for the ESUs addressed by the plan, since a determination of these criteria is a NMFS decision.

recovery scenarios: Alternative combinations of target status for the populations in an ESU that would be generally consistent with TRT recommendations for ESU viability.

recovery strategy: Statements that identify the assumptions and logic – the rationale – for the species' recovery program.

redd: A nest constructed by female salmonids in streambed gravels where eggs are fertilized and deposited.

riparian area: Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland.

salmonid: Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.

smolt: A juvenile salmonid that is undergoing physiological and behavioral changes to adapt from freshwater to saltwater as it migrates toward the ocean.

spatial structure: Characteristics of a fish population's geographic distribution. Current spatial structure depends upon the presence of fish, not merely the potential for fish to occupy an area.

stakeholders: Agencies, groups, or private citizens with an interest in recovery planning, or who will be affected by recovery planning and actions.

Technical Recovery Team (TRT): Teams convened by NMFS to develop technical products related to recovery planning. TRTs are complemented by planning forums unique to specific states, tribes, or regions, which use TRT and other technical products to identify recovery actions.

threatened species: A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

threats: Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

viability criteria: Criteria defined by NMFS-appointed Technical Recovery Teams to describe a viable salmonid population, based on the biological parameters of abundance, productivity, spatial structure, and diversity. These criteria are used as technical input

into the recovery planning process and provide a technical foundation for development of biological delisting criteria.

viability curve: A curve describing combinations of abundance and productivity that yield a particular risk of extinction at a given level of variation over a specified time frame.

viable salmonid population (VSP): an independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame.

VSP parameters: Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, *Viable salmonid populations and the recovery of evolutionarily significant units* (McElhany et al. 2000).

Acronyms and Abbreviations

A/P	abundance/productivity
BACI	Before-After-Control-Impact
BLM	Bureau of Land Management
CAO	Critical Areas Ordinance
CCRP	Continuous Conservation Reserve Program
CEO	County Environmental Ordinance
cfs	cubic feet per second
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CRITFC	Columbia River Inter-tribal Fish Commission
CRP	Conservation Reserve Program
CSMEP	Collaborative Systemwide Monitoring and Evaluation Project
CSP	Conservation Security Program
CUPs	Conditional Use Permits
CZO	County Zoning Ordinance
DPS	Distinct Population Segment
Ecology	Department of Ecology
EDT	Ecosystem Diagnostic and Treatment
EIS	environmental impact statement
EKCD	Eastern Klickitat Conservation District
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FEIS	final environmental impact statement
FPO	Floodplain Management Ordinance
FREP	Forestry Riparian Easement Program
FY	fiscal year
GMA	Growth Management Act
GRP	Grassland Reserve Program
HFRP	Healthy Forest Reserve Program
ICTRT	Interior Columbia Technical Recovery Team
MaSA	Major Spawning Area
MOA	Memorandum of Agreement
MiSA	Minor Spawning Area
MPG	Major Population Group
NMFS	National Marine Fisheries Service
WDFW	Wahington State Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
NOAA	National Oceanic and Atmospheric Administration-Fisheries
NPCC	Northwest Power and Conservation Council
NRCS	Natural Resources Conservation Service
PCSRF	Pacific Coastal Salmon Recovery Fund
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
RCW	Rock Creek Watershed
QAR	Quantitative Analytical Report
RM	River-mile
SDPs	Substantial Development Permits
SEPA	State Environmental Policy Act
SMP	Shorelines Master Plan
SRFB	Salmon Recovery Funding Board
SS/D	Spatial structure/diversity
SSB	Substitute Senate Bill
TNC	The Nature Conservancy
TRT	Technical Recovery Team
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
VARs	Variances
VSP	Viable Salmonid Population
WAC	Washington Administrative Code
WCC	Washington Conservation Commission
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WHIP	Wildlife Habitat Incentive Program
W/LC TRT	Willamette/Lower Columbia Technical Recovery Team
WRIA	Water Resources Inventory Area
WRP	Wetlands Reserve Program
WY	Water Years
YN	Yakama Nation

Executive Summary

The Endangered Species Act of 1973 (ESA) requires NOAA's National Marine Fisheries Service (NMFS) to develop recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA.

This plan focuses on the conservation and survival of Middle Columbia River steelhead (*Oncorhynchus mykiss*) in the Rock Creek subbasin. Rock Creek drains an area of 223.2 sq. miles (578.1 sq. km) in southeastern Washington State. It joins the Columbia River at RM 230, approximately 12 miles upstream of John Day Dam (Figure ES-1). This is one of several recovery plans developed for independent populations of the Middle Columbia River steelhead distinct population segment (DPS), which was listed as threatened under the ESA on March 25, 1999 and reconfirmed on January 5, 2006 (71 FR 834). Similar plans have been prepared for Middle Columbia steelhead populations in the White Salmon River, Klickitat River, and Yakima River, as well as in areas of southeast Washington and the State of Oregon. These separate plans are part of a DPS-level plan that integrates recovery actions across the DPS.

Purpose of Plan

A recovery plan is a guidance document, not regulatory. This plan provides a roadmap for restoring the Rock Creek steelhead population and its habitats to a level that supports recovery of the Middle Columbia River steelhead DPS and allows the population to become a viable component of its ecosystem.

The plan describes the current status of the Rock Creek population and proposes a strategy for its conservation and recovery. The recovery strategy builds on past and current recovery efforts. A key component of the strategy is collaborative development of a research, monitoring, and evaluation plan to further characterize population and habitat characteristics. Finally, the plan provides guidelines for implementation and an adaptive management framework for making appropriate adjustments as new information becomes available.

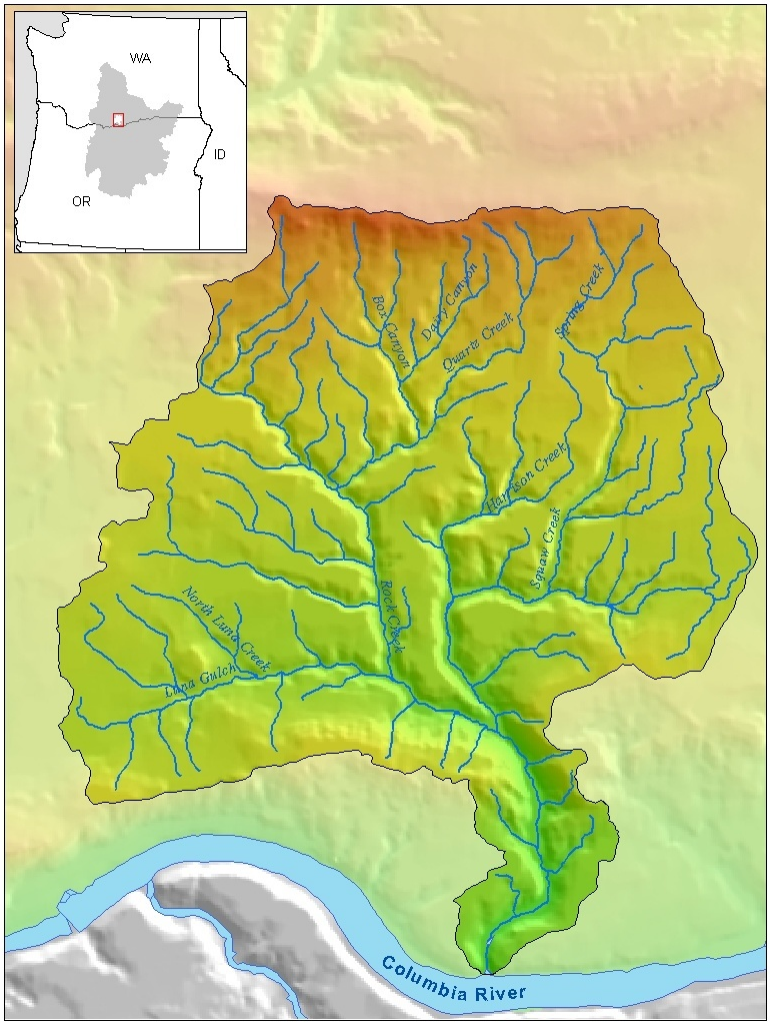


Figure ES-1. Rock Creek Subbasin.

Context of Plan Development

The plan is the product of a process initiated by NMFS; it incorporates information from the Yakama Nation (YN), Washington Department of Fish and Wildlife (WDFW), Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal agencies, state agencies, local governments, and the public.

Currently, there are 19 ESA-listed ESUs/DPSs of Pacific salmon and steelhead in the Pacific Northwest. For the purpose of recovery planning for these species, NMFS Northwest Region designated five geographically based "recovery domains" (Figure ES-2). The range of the Middle Columbia River steelhead DPS is located in the Middle Columbia sub-domain of the Interior Columbia domain.

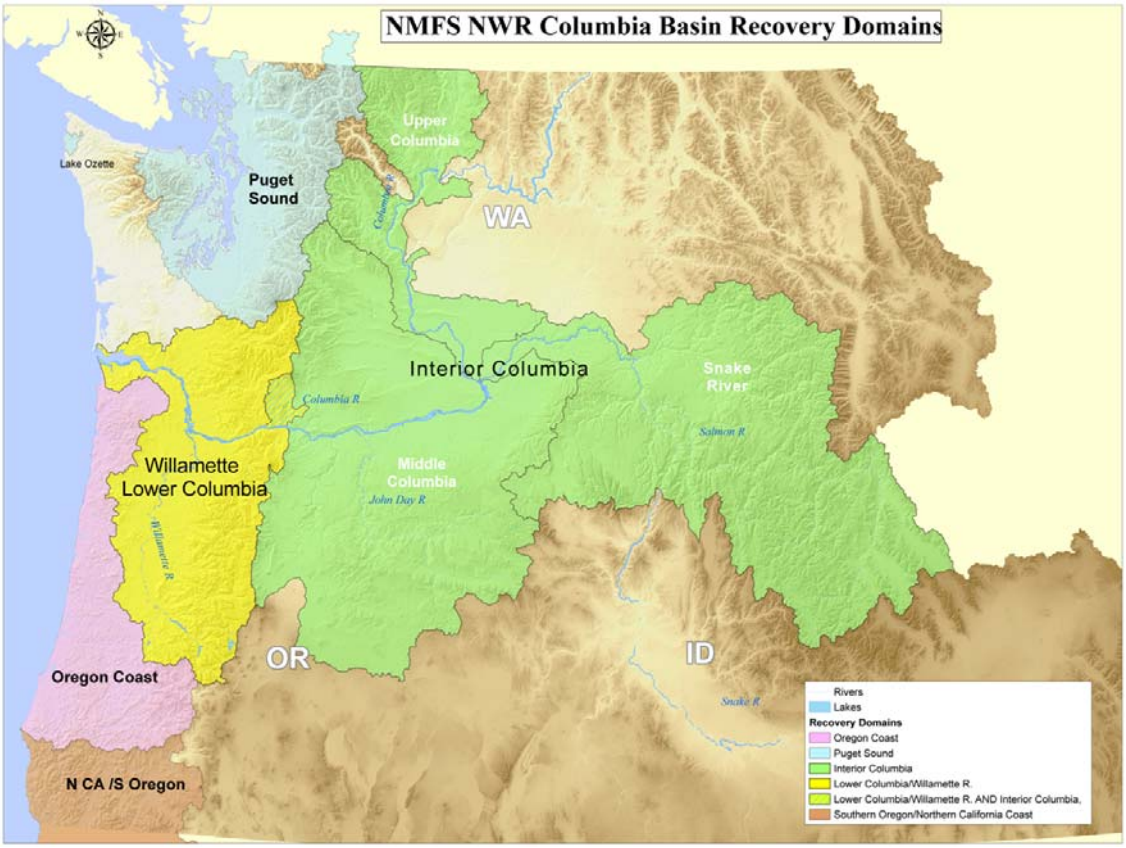


Figure ES-2. Columbia Basin Recovery Domains for NMFS Northwest Region.

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each Technical Recovery Team (TRT) was to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. The Interior Columbia TRT (ICTRT) includes biologists from NMFS, states, tribes, and academic institutions.

All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population viability criteria – criteria that may be used, along with criteria based on mitigation of the factors for decline, in determining whether a species has recovered sufficiently to be downlisted or delisted. These principles are described in a NMFS technical memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000).

Viable salmonid populations (VSP) are defined in terms of four parameters: abundance, productivity (growth rate), spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework, based on data availability, the

unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs are working from a common scientific foundation. Viability criteria are an important part of recovery goals, as described later in this summary.

The Rock Creek Plan reflects direction for Rock Creek steelhead adopted into the Northwest Power and Conservation Council's (NPCC) Fish and Wildlife Program subbasin plan (NPCC 2004). The subbasin plan was produced through a collaborative process involving the Yakama Nation, Washington Department of Fish and Wildlife, and NPCC. In addition, the plan reflects technical data drawn from the following sources:

- Watershed Resource Inventory Area (WRIA) 31 Watershed Assessment (Aspect and WPN 2004) and WRIA 31 Instream Habitat Assessment (Glass 2009)
- The Interior Columbia Technical Recovery Team (ICTRT) viability criteria and current status assessment for the Middle Columbia River steelhead DPS (ICTRT 2007a, 2007b, and 2009)

Biological Background

Salmonid species' homing propensity (their tendency to return to the locations where they originated) creates unique patterns of genetic variation and connectivity that mirror the distribution of their spawning areas across the landscape. Diverse genetic, life history, and morphological characteristics have evolved over generations, creating runs highly adapted to diverse environments. It is this variation that gives the species as a whole the resilience to persist over time.

Historically, a salmon ESU or steelhead DPS typically contained multiple populations connected by some small degree of genetic exchange that resulted from some spawners "straying" into neighboring streams. Thus, the overall biological structure of the ESU/DPS is hierarchical; spawners in the same area of the same stream will share more characteristics than those in the next stream over. Fish whose natal streams are separated by hundreds of miles will have less genetic similarity.

Definition of Evolutionarily Significant Units/Distinct Population Segments
An ESU is defined as a group of Pacific salmon that is "substantially reproductively isolated from other conspecific units and represents an important component of the evolutionary legacy of the species" (Waples 1991). A "population segment" is considered distinct (a DPS and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics; or if it occupies an unusual or unique ecological setting; or if its loss would represent a significant gap in the species' range (71 FR 834).

ESUs/DPSs may contain multiple populations that are connected by some degree of genetic exchange through straying, and hence may have a broad geographic range across watersheds and river basins.

Major Population Groups
Within an ESU/DPS, independent populations can be grouped into larger populations that share similar genetic, geographic, and/or habitat characteristics (McClure et al. 2003). These "major groupings" of populations (MPGs) are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between ESUs/DPSs.

Independent Populations
McElhany et al. (2000) defined an independent population as follows:

"…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season."

The Rock Creek population is one of 17 extant independent populations that make up the Middle Columbia River steelhead DPS, and one of the five extant populations (Klickitat River, Fifteenmile Creek, Rock Creek, Deschutes River Eastside, and Deschutes River Westside) and two extirpated populations (White Salmon River and Deschutes Crooked River) that make up the major population group (MPG) of the Cascades Eastern Slope Tributaries (Figure ES-3). Steelhead in this MPG occupy diverse habitats, generally those draining the eastern slopes of the Cascades and the Columbia Plateau.

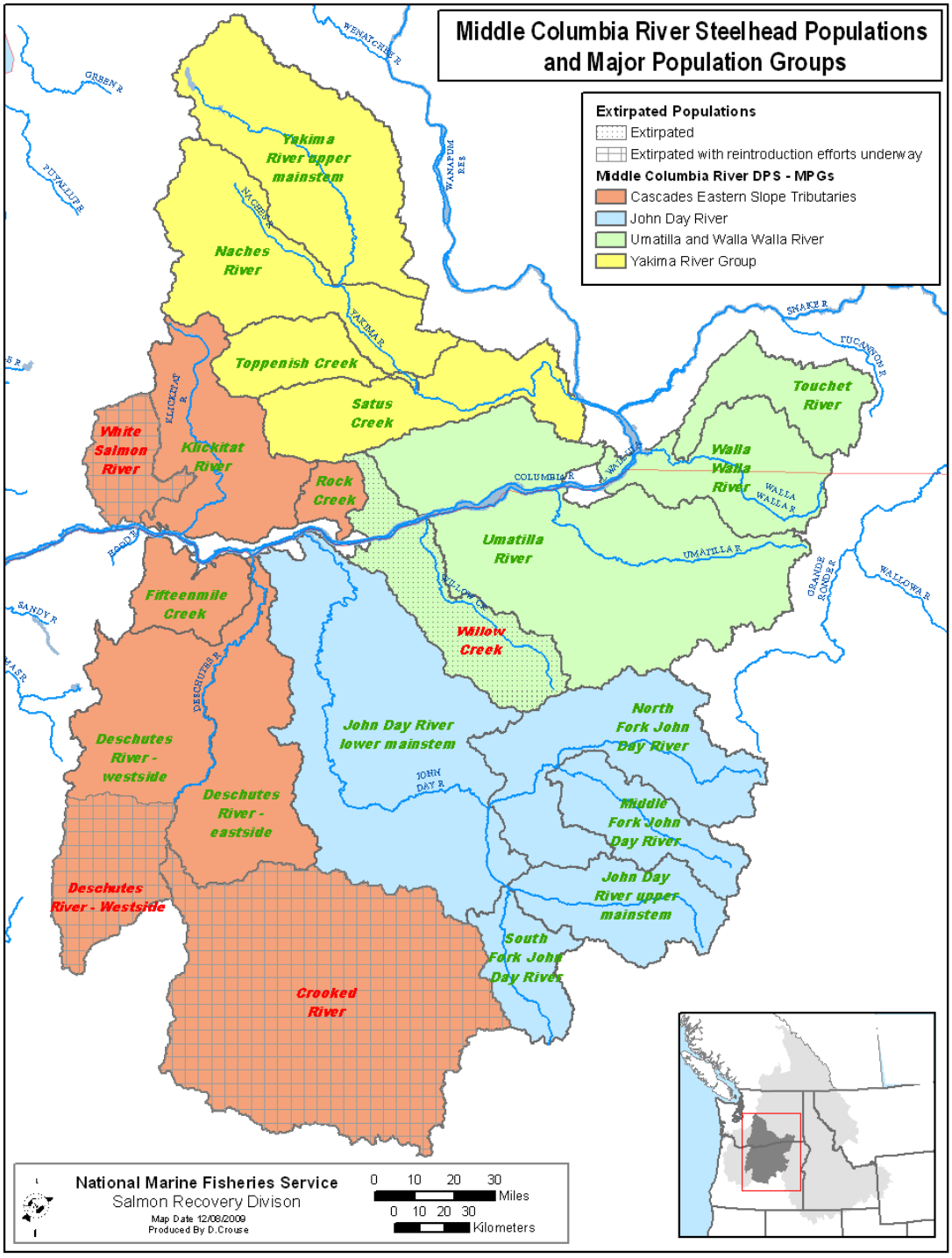


Figure ES-3 Middle Columbia River Steelhead Populations and Major Population Groups.

Physical Setting

Rock Creek begins in the Simcoe Mountains, which form the subbasin's northern border and the southern edge of the Yakama Indian Reservation. Major tributaries to Rock Creek include Badger Gulch, Harrison Creek, Luna Gulch, Quartz Creek and Squaw Creek. Lake Umatilla, the reservoir behind John Day Dam on the Columbia River, inundates the lower mile of Rock Creek.

The drainage has a high basalt plateau and deeply incised canyons that reflect its underlying basalt geology. Headwater streams cross a relatively flat basalt plateau that is primarily forested and above known anadromous use, and then drop into steep-walled canyons where gradients increase to 2 to 4 percent or more. Flows in the subbasin's canyon and alluvial reaches are considered flashy, rising and falling rapidly in response to precipitation and snowmelt. Snowmelt runoff from higher elevations appears to help sustain flows into early spring. Numerous springs also exist in the subbasin, most of which are located in the headwaters (Brown 1979). No flow regulation occurs in the drainage, although small amounts are diverted for stock watering.

Lands in the Rock Creek subbasin remain generally undeveloped, with nearly 47 percent rangeland, 26 percent forestland, and 4 percent dry land agriculture. Forests cover the upper elevations, and the middle and lower watershed supports range and agricultural uses. No irrigated land was estimated to exist as of 2001 (Aspect Consulting and WPN 2004). Developed land accounts for less than one percent of the subbasin area (Aspect Consulting and WPN 2004).

Rock Creek Steelhead Population

Steelhead in Rock Creek are considered indigenous. Rock Creek is a natural production area, with no hatcheries located in the subbasin, although it is possible that some strays from outside hatchery sources enter Rock Creek. The stock is considered distinct from other mid-Columbia stocks based on geographic isolation of the spawning population (ICTRT 2003).

Limited information exists on steelhead abundance in the Rock Creek drainage; however, some observations suggest that a significant number of steelhead may utilize the Rock Creek watershed in good water and ocean condition years. Surveys conducted by the Yakama Nation in lower Rock Creek in 2002, 2003 and 2004 show as many as 35 to 45 steelhead redds per mile in the lower five miles, and extensive distribution of redds throughout the watershed. Steelhead spawner surveys conducted in 2008 found 2 to 3 redds per mile (Glass 2009). More surveys are needed to determine steelhead abundance in the drainage. Efforts are underway to model the abundance and capacity within the watershed (J. Spencer, pers. comm. 2006).

Historically, steelhead likely utilized virtually all of the major streams and tributaries of Rock Creek for some part of their life history. Spawning distribution probably included all accessible portions of the Rock Creek watershed. As now, the highest spawning densities likely occurred in the more complex, braided reaches of the lower mainstem of

Rock Creek, and in third- and fourth-order tributaries with moderate (1-4 percent) gradients (NPCC 2004). The headwaters of the mainstem and Box Canyon are generally above known anadromous fish use (NPCC 2004); however, live steelhead, redds and *O. mykiss* fry have been observed up to the falls in Box Canyon.

All steelhead in the Columbia River Basin upstream of The Dalles Dam, including the Rock Creek population, are classified as summer-run fish (Chapman et al. 1994; ICTRT 2009); however, Yakama Nation biologists suspect that a portion of the steelhead population in Rock Creek consists of winter-run fish.

Recovery Goals and Criteria

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act – i.e. to be delisted. Delisting criteria are applied at the DPS level, and are based on determinations of the viability of the independent populations that make up the DPS. Criteria for delisting the Middle Columbia steelhead DPS are described in the Middle Columbia River Steelhead ESA Recovery Plan, to which this plan is an appendix. The primary goal of this plan is for the Rock Creek steelhead population to be restored to moderate risk, also called "maintained," status and thus to support recovery of the Mid-Columbia steelhead DPS.

Two kinds of criteria enter into a delisting decision: population or demographic parameters (the biological viability criteria) and "threats" criteria related to the five listing factors detailed in the ESA (see Section 1.1). The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B). Both kinds of criteria are discussed in Chapter 3.

Biological Criteria

The ICTRT developed biologically based viability criteria for ESA-listed salmon and steelhead in the Interior Columbia domain. The ICTRT based its approach to recovery on guidance from the NMFS Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). This memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels.

A viable salmonid population is defined as an independent population that has negligible (less than 5 percent) risk of extinction over a 100-year period (McElhany et al. 2000). The ICTRT criterion for a viable ESU/DPS is that all extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS should be at low risk. The ICTRT provided additional criteria for determining MPG viability (Section 3.2.1). The risk levels of the populations within the DPS collectively determine MPG viability and, in turn, the likely persistence of the DPS. However, it may not be necessary for all of the populations to attain the lowest risk level. There may be more than one way for a DPS to meet the viability criteria. The ICTRT called alternative combinations of population risk status that would meet the MPG and DPS-level criteria "recovery scenarios."

According to the ICTRT's recovery scenario for the Cascades Eastern Slope Tributaries MPG, the Rock Creek steelhead population should reach "moderate" risk status in order to support overall DPS viability. Moderate risk is defined as between 25 and 5 percent risk of extinction over a 100-year time period.

The ICTRT classified the Rock Creek steelhead population as a "Basic" sized population, based on historical habitat potential (ICTRT 2007b) and provided viability criteria for a Basic population, as follows (ICTRT 2007b):

Abundance
For a Basic population, viable status, i.e. a 5 percent or less risk of extinction over a 100-year timeframe, would require a mean minimum abundance threshold of 500 naturally produced spawners. Maintained status or moderate (6 to 25 percent) risk would also require a mean minimum abundance of 500 naturally produced spawners because populations with fewer than 500 individuals are at higher risk for inbreeding depression and a variety of other genetic concerns (ICTRT 2007b).

Productivity
Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels. For a maintained/moderate risk Basic population at 500 naturally produced spawners, productivity should be at about 1.3. For the population to reach viable status (the 5 percent risk level), productivity should be >1.56.

Spatial Structure and Diversity
In general, the ICTRT defined two goals, or biological or ecological objectives, that spatial structure and diversity criteria should achieve (ICTRT 2007b):

- Natural rates and levels of spatially mediated processes should be maintained.
- Natural patterns of variation should be maintained.

Threats Criteria and Approach

Section 3.2.2 of the Plan describes the listing factors and listing/threats criteria that must also be addressed to de-list the DPS. These listing factors are the features that were evaluated under section 4(a)(1) when the initial determination was made to list the species for protection under the ESA.

At the time of a delisting decision, NMFS will use the listing factors/threats criteria to review the status of the section 4(a)(1) listing factors and determine if the affected DPS is recovered to the point that it no longer requires protections of the ESA. NMFS expects that if the proposed actions described in this and other Middle Columbia River steelhead recovery plans are implemented, they will make substantial progress toward meeting the listing factor/threats criteria. These criteria are identified in Section 3.3 and address the five listing factors that were evaluated under section 4(a)(1): 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) over-utilization for

commercial, recreational, scientific or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting its continued existence.

Current Status Assessment

Chapter 4 summarizes the ICTRT's viability assessment results for Rock Creek's Middle Columbia River steelhead population. The ICTRT identified the Rock Creek steelhead population as a summer run within the Cascades Eastern Slope Tributaries MPG. It classified the population as a "basic" population based on historical habitat potential (ICTRT 2007b).

- *Abundance/Productivity:* The ICTRT determined that, at present, no direct estimates of abundance and productivity are available for Rock Creek steelhead. There have been no systematic redd surveys in this population area; however, the general presence of steelhead has been documented. Because of the lack of direct information on current or indirect assessments of abundance and productivity, the ICTRT assigned the Rock Creek steelhead population High risk.

- *Spatial Structure and Diversity:* The ICTRT gave the Rock Creek population a combined integrated Spatial Structure/Diversity rating of Moderate risk. Based on the ICTRT historical potential analysis, the team found that the Rock Creek population has a relatively simple population structure, containing a single major spawning area (MaSA). It determined that although observations indicate that steelhead spawning may occur across much of the historical range, the relatively simple population structure results in a moderate risk rating for complexity. It noted that there have likely been minor reductions in life history diversity and phenotypic variation, but these changes are not severe enough to raise risk levels above low for this parameter.

- *Overall Risk Rating*: The ICTRT concluded that the Rock Creek steelhead population does not currently meet viability criteria because the abundance/productivity parameter is assigned a High risk rating and the overall spatial structure/diversity parameter, Moderate risk. The lack of direct estimates of abundance and productivity for this population was a factor in assigning a high risk rating (ICTRT 2009).

Limiting Factors and Threats

The reasons for a species' decline are generally described in terms of limiting factors and threats. Analysis of limiting factors and threats across the entire species' life cycle forms the basis for designing recovery strategies and actions. NMFS defines limiting factors as the biological and physical conditions limiting DPS and population status (e.g. elevated water temperature), and defines threats as those human activities or naturally induced actions that cause the limiting factors (e.g. removal of riparian vegetation for agricultural or residential purposes, which causes loss of shade and, consequently, elevated water temperature).

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are typically legitimate human activities that may at times have unintended negative consequences on fish populations—and that can also be managed in a way that minimizes or eliminates the negative impacts.

For steelhead and other salmonids, survival to reproduce depends on a complex, interacting system of environmental conditions, with different conditions needed for each life stage. Optimal water temperature, for example, varies (within limits) for adult migration vs. egg incubation or juvenile rearing. In addition, the particular factors limiting production may vary across different sections of the tributary drainage used by a particular population. Data on a full range of potential limiting factors is rarely available at the reach level.

The list of potential limiting factors for the Rock Creek steelhead population, as for the other populations that make up the Middle Columbia steelhead DPS, is based on a substantial body of research on salmonids, local field data and field observations, and the considered opinions of regional experts. These are implicitly hypothetical statements to be tested, made with the expectation that by taking action in the face of some degree of scientific uncertainty, monitoring the results, continuing to conduct research to further characterize the factors limiting the population, and adapting our management actions in response, the state of our knowledge will improve and so will the survival of these fish, although not necessarily in a directly parallel process.

Freshwater Habitat

Habitat factors (e.g. temperature) may limit steelhead production in the Rock Creek watershed and, to some extent past and/or current land use practices may constitute threats that stress naturally occurring conditions. For example, anthropogenic changes in the subbasin may have reduced stream shade in some reaches and thereby increased the intensity of low summer flows and high summer water temperatures that likely occur naturally in some parts of the watershed because of aspect, low precipitation and high width-to-depth ratios.

The factors potentially limiting freshwater steelhead productivity within the Rock Creek watershed include degraded channel structure and complexity (lack of key habitat quantity and habitat diversity), riparian function and condition, and floodplain function and channel migration processes; low summer flows, high summer water temperatures, increased fine sediment, altered food web, predation, and competition with exotic species such as smallmouth bass. Section 5 provides more detail on limiting factors.

- *Hydrograph*: Seasonally low to intermittent and/or subsurface stream flows are potentially a primary factor that limits steelhead production in the Rock Creek. The hydrograph in the Rock Creek system is naturally flashy, with high intensity, short duration flow. Currently, low to nonexistent flows in the mainstem and many tributaries during late summer, fall and early winter might limit juvenile steelhead production and mobility. In 2008, sufficient pool volume was available

to support an estimated population of 38,300 to 95,700 age-0 steelhead (Glass 2009).

- *Stream temperature:* Seasonally high water temperature is potentially a primary factor limiting steelhead production in the Rock Creek watershed (Glass 2009). Average daily summer water temperatures in the lower Rock Creek subbasin sometimes rise above 63.5°F (17.5°C), and in some reaches rise above 73.4°F (23.9°C) (Aspect Consulting 2005), a level considered potentially lethal for steelhead and other salmonids (Glass 2009). One headwater reach of Rock Creek is listed on the Washington State Department of Ecology's 2008 water quality assessment (303(d) list as impaired, Category 5 (Washington Department of Ecology 2008).

- *Riparian function and condition*: Rock Creek's rocky substrate and steep topography inhibit riparian forest stand development along many reaches. However, current riparian condition and function in some sections of Rock Creek have been disturbed due to wildfires, recent major flood events, past and current grazing, historical timber practices, road construction, and/or other land uses. Despite these influences, the amount of vegetation in the valley bottom has been increasing steadily since 1938, presumably due to fire suppression (Aspect Consulting 2005).

- *Channel structure and complexity:* Findings from a reconnaissance survey of portions of Rock Creek indicate that the creek's general channel characteristics may be similar to those noted in a 1860s survey (e.g., broad rocky reaches), with the exception that the lowermost reach may be somewhat wider today than historically (Aspect Consulting and WPN 2004). In-channel and riparian habitats in some stream reaches may be degraded because of disturbance from grazing, historic timber harvest, road construction, and other anthropogenic changes, and from major flood events. Inundation of the one-mile reach above Rock Creek's mouth by the pool behind John Day Dam (Columbia River) has altered key habitat quantity and complexity.

- *Floodplain function and channel migration processes*: The effects from several threats locally influence channel migration processes and morphology. Bridges on the Bickleton Highway (scheduled for replacement) and Old Highway 8 locally constrain flow and channel migration processes. The stream channel in lower Rock Creek is highly dynamic and moves across the valley bottom with regularity, often switching channels during flood flows (Aspect Consulting 2005). One of the more dynamic sections of the stream channel is upstream of the Old Highway 8 Bridge, where the channel changed courses many times over the period of photo record, and has distinctly different courses in 1938, 1969, 1996, and 2002 (Aspect Consulting 2005). This section of the creek also is one of the least densely vegetated along the mainstem of Rock Creek (Aspect Consulting 2005), reflecting the dynamic nature of the channel.

- *Sediment routing:* Sediment loads (the percentage of fines in spawning gravel, embeddedness and turbidity) in the Rock Creek subbasin may have increased over historical conditions; however, recent data indicates that the percent fines in spawning gravels is within a range that is unlikely to significantly affect survival of eggs and alevins in redds (Glass 2009).

- *Competition for food sources:* Changes in the hydrologic regime and riparian conditions could potentially affect the food web. No data are available regarding food sources in Rock Creek.

- *Predation and competition*: The building of the John Day Dam and subsequent inundation of the bottom mile of Rock Creek introduced exotic piscivorous fish such as smallmouth bass and channel catfish to the lower mile and reservoir and made it possible for these fish to travel up Rock Creek. Exotic piscivorous species have been observed in Rock Creek up to approximately one mile above the Old Hwy. 8 bridge (RM 3.5-4) (G. Morris, pers. comm. 2006). However, no exotic fish were observed upstream of the inundated area of the creek during snorkel surveys conducted in 2008 (Glass 2009).

Harvest

Without more data on Rock Creek steelhead abundance, and without targeted tagging of Rock Creek fish, the percentage of Rock Creek steelhead that are harvested in the Columbia River cannot be specifically calculated. However, it may be inferred that Rock Creek steelhead are subject to the same relatively low overall harvest rate estimated for other Middle Columbia steelhead. Washington Department of Fish and Wildlife (2008) estimates that in 2002, tributary fisheries in the Rock Creek area affected about 1 percent of the adult steelhead and less than 1 percent of the juvenile steelhead. Mainstem non-treaty commercial and recreational fisheries have an estimated impact of 1.6 percent of the A-run Middle Columbia steelhead (NMFS 2008a), and mainstem treaty fisheries have an estimate 6.64 percent impact (NMFS 2008a) for an overall estimated harvest impact of less than 10.24 percent.

Hatcheries

Steelhead are not stocked in Rock Creek, and very few fin-clipped steelhead have been seen in the subbasin. Hatchery strays of upriver origin may enter and spawn in Rock Creek, but the effects of out-of-subbasin hatchery programs on the Rock Creek steelhead population are unknown. Nevertheless straying, especially by non-indigenous hatchery steelhead, remains a concern.

Out-of-Subbasin Limiting Factors and Threats

Out-of-subbasin factors are discussed briefly in Section 5.3 and provide information on the influences from harvest, the Columbia River hydrosystem, and ocean conditions. The 2008 FCRPS Biological Opinion (NMFS 2008b) details the influences from the Columbia River hydrosystem on Middle Columbia steelhead populations. The Columbia River Estuary Module http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-

Recovery -Plans/upload/Estuary-Module.pdf discusses factors that limit viability of Rock Creek steelhead in the Columbia River Estuary.

Recovery Strategy and Actions

In Chapter 6, a recovery strategy is described to address the significant data gaps and uncertainties regarding the status of the Rock Creek steelhead population and to address the potential limiting factors based on the existing, best available science. In addition, Appendix II details the many efforts already underway to improve and protect watershed conditions in the Rock Creek subbasin—efforts that will benefit salmonids as well as other wildlife and human communities.

The overall aim of the recovery strategy is to gather needed data on the Rock Creek steelhead population and the watershed, while also addressing the potential limiting factors in a manner that is most likely to contribute to improved viability. The strategies and actions were defined through review and analysis of currently available information. They are consistent with actions identified in the Lower Mid-Columbia Mainstem Subbasin (including Rock Creek) Management Plan (NPCC 2004), and address risks identified in the ICTRT's viability assessment for the population. A collaboratively designed implementation program that includes a research, monitoring, and evaluation (RM&E) plan to support adaptive management will allow managers the flexibility to continue or change course in response to new information.

Gather Information on VSP Parameters

Information on population abundance, productivity, spatial structure, and diversity is needed to set priorities and determine the actions that will make the greatest contribution to steelhead recovery. Needed actions include initiating systematic surveys to calculate abundance and productivity, completing a gap analysis, characterizing spatial distribution and genetic variation, and evaluating hatchery contribution to naturally spawning steelhead in the Rock Creek subbasin.

Protect and Conserve Existing Good Quality Habitat

Protecting existing good quality habitat is a high priority. Many objectives are likely to be met through habitat protection and the associated natural recovery of upland and riparian areas. Protection and maintenance includes compliance with existing rules and regulations, such as the State Forest Practices Act, the State Shorelines Act, and other State, County, and local regulations designed to protect aquatic habitat. Protection may also incorporate a wide range of voluntary actions such as fencing riparian areas, participation in the various agricultural land reserve programs, and voluntarily implementing programs that help to avoid impacts to aquatic resources. Land acquisitions, easements, cooperative agreements, and protective land designations can also be used to facilitate high quality habitat protection.

Restore and Enhance Habitat and Gather Information

Restoration and enhancement of habitat conditions for salmon and steelhead populations should improve population production. The value of these actions to the viability of the population will depend on whether or not they address the factors currently limiting the population or threats associated with factors that are now, or are trending toward, becoming limiting, e.g. climate change. The success of these strategies is further enhanced when actions build from existing restoration efforts and incorporate a range of project types.

- Conduct research to further evaluate factors and threats limiting habitat diversity in the Rock Creek watershed. This information is needed to prioritize and focus restoration and enhancement activities.

- Improve instream flow during critical periods. The seasonally low to intermittent stream flow in the area of steelhead distribution upstream of the Columbia River backwater is a likely limiting factor on abundance, productivity, spatial structure, and diversity. Low flow can result in stranding and mortality to eggs or juvenile steelhead. Further study is required to determine causes of low flow, whether anthropogenic or natural, and options to enhance stream flow.

- Improve water quality, reduce summer high temperatures. Water temperature is directly related to riparian vegetative cover and other watershed characteristics such as channel complexity, floodplain function, and upland processes. Hence, many types of habitat actions are likely to function together to improve water quality, particularly water temperature. The more directly related actions to improve water quality include the following:
    - Restore riparian vegetative cover with appropriate native vegetation to increase shading.
    - Develop sediment control basins.
    - Manage livestock grazing in the riparian areas.
    - Increase deep pool habitat.

- Improve/restore riparian function and condition. Actions to address this potential limiting factor include the following:
    - Restore riparian vegetative cover with appropriate native vegetation.
    - Manage livestock grazing in riparian areas.
    - Eradicate invasive plant species from riparian areas.
    - Relocate beaver to suitable areas.

- Increase key habitat by improving or restoring channel structure and complexity. Key habitat, as described in Chapter 5, refers to characteristics such as riffles, pools, suitably aerated gravel, etc. that are essential to each steelhead life stage. The following actions would increase key habitat:
    - Introduce large woody debris (LWD) and other structures in stream as appropriate.
    - Improve riparian vegetation to provide future source of LWD.
    - Stabilize and protect stream banks.

- Fertilize streams with fish carcasses.

- Improve and/or restore floodplain function and channel migration processes. Reconnecting floodplain habitats and side channels would provide additional sheltered rearing areas. Increasing LWD and other actions such as relocating floodplain infrastructure where feasible, implementing road management BMPs or decommissioning roads as appropriate, could restore floodplain function, moderate the "flashiness" of the stream, and moderate peak flows.

- Improve or restore optimal sediment processes. Watershed processes of runoff and sediment production can be improved through restoring native upland plant communities, implementing appropriate upland management practices, managing off-road vehicle usage to reduce erosion and fine sediment, and managing roads to reduce fine sediment inputs to the stream.

- Conduct research to determine status of food web and presence or absence of competition from other species for food resources.

- Conduct research to determine presence and extent of predation on steelhead by non-native species such as piscivorous fish.

Review and Reduce Effects of Harvest

As described in Chapter 5, only adipose fin-clipped steelhead are allowed to be retained in sport or recreational fisheries in Rock Creek and throughout the Columbia River, but wild steelhead may be accidentally caught and/or retained. Poaching is also considered a problem. Actions to address harvest effects include better review of current practices, enforcement of regulations, and considering whether any modifications are needed. Outreach and education to reduce retention or handling mortality is also recommended.

Research Effects of Hatchery Fish (If Any)

As described in Chapter 5, hatchery strays of upriver origin may enter and spawn in Rock Creek, but no data are available on this issue. Monitoring for hatchery fish should be included in the RM & E program to be developed collaboratively after this plan is adopted.

Address Out-of-Subbasin Limiting Factors

Out-of-subbasin limiting factors for Rock Creek steelhead may include hydroelectric operations, harvest, interactions with hatchery fish, predation, food, disease, competition, and ocean conditions. Actions to address these factors for all Middle Columbia steelhead are presented in the Columbia River Estuary Module (NMFS 2007b) and the 2008 FCRPS Biological Opinion (NMFS 2008b), summarized in the Hydro Module (NMFS 2008c). Table ES-1 summarizes the recovery strategy designed to improve the viability of Rock Creek steelhead. The table links strategies and actions to the factors and threats potentially limiting steelhead viability in the subbasin, and the viability parameters and life stages that would be most affected. Priority locations are provided for some

strategies, with stream reaches or areas where actions should be applied first to gain the greatest benefit.

Table ES-1. Recovery Strategy and Actions for the Rock Creek Population of Middle Columbia Steelhead.

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
Gather information on population size and productivity	• Gather information to calculate abundance and productivity estimates	Entire Watershed	Addresses a primary risk factor	N/A	N/A	abundance and productivity	N/A
Gather information on population spatial structure and diversity	• Conduct surveys to determine steelhead distribution. • Identify major life history strategies • Conduct studies to address genetic variation in the population • Assess the contribution of hatchery-origin steelhead to the natural spawning population	Entire Watershed	Addresses a primary risk factor	N/A	N/A	spatial structure and diversity	N/A
Gather information to further evaluate habitat limiting factors and threats in the basin	• Conduct surveys to evaluate factors affecting habitat quantity. • Conduct surveys to evaluate factors affecting habitat quality. • Conduct surveys to evaluate factors affecting habitat function.	Entire Watershed	Addresses a primary risk factor	N/A	All life stages	All VSP parameters	N/A
Protect and conserve natural ecological processes that support steelhead viability throughout the life cycle	• Apply BMPs to livestock grazing practices • Apply BMPs to road system management • Apply BMPs to agricultural practices to control erosion and runoff • Manage stream corridor through conservation easements and/or land acquisition from willing sellers • Adopt and manage cooperative agreements	Throughout watershed	Key habitat quality and diversity, sediment inputs, water quality, stream flow	Road and grazing management activities	All life stages	abundance, productivity, spatial structure and diversity	Immediate for sediment, other parameters 5-15 years

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
Improve instream flow during critical periods	• Most of the actions listed in other categories are likely to improve stream flow. • Protect springs	Rock Creek downstream of RM 19.2, lower Squaw Creek, upper watershed	Channel morphology, habitat diversity, key habitat quantity, fine sediment, flow, water tempera-ture, thermal refugia, altered food web	Road and grazing management, channelization	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve water quality, reduce summer water temperatures	• Restore riparian vegetative cover with suitable native vegetation to increase shading • Restore natural habitat functions and processes through actions previously identified • Develop sediment control basins • Management livestock grazing in the riparian areas • Increase deep pool habitat	Rock Creek downstream of RM 19.2, lower Squaw Creek, upper watershed	Channel morphology, habitat diversity, key habitat quantity, fine sediment, flow, water temperature, thermal refugia	Road and grazing management,, particularly in riparian areas, channelization	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve and/or restore riparian function and condition	• Restore riparian vegetation cover with appropriate native vegetation • Manage grazing in riparian areas • Eradicate invasive plant species from riparian areas • Relocate beaver to suitable areas	Rock Cr. Below unnamed trib. at RM 19.2, Luna Gulch, lower Squaw Cr.	Hydrology, channel stability, fine sediment, water quality, key habitat quantity, habitat diversity, riparian vegetation	Road and grazing management activities	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve and/or restore channel structure and complexity	• Introduce LWD and other structure in stream as appropriate • Improve riparian vegetation to provide future source of LWD • Stabilize and protect stream banks • Fertilize streams with fish carcasses	Rock Creek downstream of RM 19.2, lower Squaw Creek, headwater streams	Channel morphology, habitat diversity, key habitat quantity, fine sediment, flow, water temperature, thermal refugia, altered food web	Road and grazing management, channelization	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve and/or restore floodplain function and	• Reconnect floodplain habitats • Reconnect side channels	Rock Cr. Below	Channel morphology,	Road and grazing	Juvenile rearing stage	abundance and productivity	0-10 years

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
channel migration processes	• Increase role and abundance of wood and large organic debris in streambeds • Relocate floodplain infrastructure, roads; improve maintenance, rehabilitate, decommission as appropriate • Remove dikes • Relocate beaver to suitable areas	unnamed trib. at RM 19.2, Luna Gulch, lower Squaw Cr.	habitat diversity, key habitat quantity, riparian vegetation, fine sediments, flow, water temperature	management activities			
Address upland processes to minimize unnatural rates of erosion and runoff	• Restore native upland plant communities • Implement upland management practices to restore natural runoff and sediment production • Implement off-road vehicle management actions that reduce erosion and fine sediment • Implement road management actions that reduce fine sediment inputs	Upper watershed	Hydrology, channel stability, fine sediment, water quality, key habitat quantity, habitat diversity, riparian vegetation	Road and grazing management activities and off-road vehicles	Egg, fry	abundance and productivity	0-50 years
Review and reduce effects of harvest on the Rock Creek steelhead population	• Review the need for modifications to sport, tribal, and commercial harvest practices on direct catch and by-catch • Increase outreach efforts to reduce the number of steelhead caught in recreational fisheries near the mouth of Rock Creek	All fishing areas in the basin, the Columbia River, and off-shore	Direct mortality	Harvest	Adult migrants	abundance	0-10 years
Research and reduce hatchery effects on the Rock Creek steelhead population	• Reduce the uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish • Monitor the potential for hatchery strays entering Rock Creek • Increase the proportion of Columbia River Basin hatchery steelhead marked with coded-wire	Columbia River and anadromous reaches of Rock Creek	Competition, genetic introgression	Hatchery releases	Juvenile and adult	abundance, spatial structure, diversity	2-10 years

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
	tags, especially in programs shown to stray at high rates in the past, and support the mass marking of all hatchery steelhead releases with, at a minimum, an adipose fin-clip						
Reduce competition with and predation by non-native piscivores	• Reduce the number of non-native predators	Columbia River and mouth of Rock Creek	Predation	Non-native species	fry and juvenile	abundance and productivity	2-20 years
Reduce mortality and/or improve passage at hydroelectric facilities	• Implement strategies and actions in the FCRPS Biological Opinion (NMFS 2008b)	Columbia River	Passage, predation, direct mortality	Hydroelectric plants	juvenile and adult	abundance	0-20 years

[1] Expected response of action implementation – including how long for action to achieve full effectiveness
[2]BLM=Bureau of Land Management, Ecology=Washington Department of Ecology, KC=Klickitat County, KCCD=Klickitat County Conservation Districts, NRCS=National Resources Conservation Service, Private=private landowners and businesses, TNC=The Natural Conservancy, WDFW=Washington Department of Fish and Wildlife, WRIA31 PU = WRIA 31 Planning Unit, YN=Yakama Nation, MNFS=National Marine Fisheries Service, ODFW=Oregon Department of Fish and Wildlife

Implementation

Implementation of this plan depends on the voluntary actions and cooperation of local entities and citizen groups. An important part of implementation will be working cooperatively to develop an implementation schedule that includes site-specific actions and a detailed research, monitoring, and evaluation (RM&E) plan addressing the information needs described in Chapter 8. A detailed RM&E plan should be developed collaboratively after the Rock Creek recovery plan is adopted.

NMFS has worked independently with the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, and local entities to develop the recovery plan for the Rock Creek steelhead population. NMFS encourages the formation of a planning group for the Washington Gorge Management Unit, a forum or entity that would take responsibility for coordinating implementation of the plan. Implementing the proposed recovery actions for steelhead in the Washington Gorge Management Unit, including the Rock Creek subbasin, would be a primary task for a Washington Gorge Area Regional Board, subject to concurrence by state, tribal, and local governments and the opportunity for involvement and comment by the public.

In addition to their co-management responsibility and key role on a Gorge recovery board (if one is formed), the Yakama Nation will play an important role during implementation because of their funding agreement under the Columbia Basin Fish Accords, which are three Memorandums of Agreement (MOAs) entered into between the Federal Columbia River Power System (FCRPS) action agencies (Bonneville Power Administration, U.S. Army Corps of Engineers and the Bureau of Reclamation), four tribes, and one state. The most relevant MOA to the Middle Columbia River steelhead is with the Columbia River Inter-Tribal Fish Commission and the three treaty fishing tribes—Confederated Tribes of the Umatilla Indian Reservation; Confederated Tribes of the Warm Springs Reservation; and Confederated Tribes and Bands of the Yakama Nation. The MOAs are 10-year action agency commitments for projects to benefit fish affected by the FCRPS, with a focus on ESA-listed fish. The projects will be reviewed through the Northwest Power Act processes for implementing the Fish and Wildlife Program, administered by the Northwest Power and Conservation Council. The agreement secures approximately $200,000 per year for habitat actions, including project management, in the Rock Creek subbasin. Some of the projects listed in Table 7.1 will be implemented with these funds.

Cost Estimates

There are existing Federal, tribal, state, county, and other local programs that are being carried out in the Rock Creek subbasin. Many of those programs are described in Appendix II. This plan assumes that those existing programs are funded, and will continue to be. At this time, this plan provides only additional incremental costs that would be incurred with implementation of this recovery plan. Total time and cost of recovery is estimated for the DPS as a whole and is iincorporated into Chapter 8 of the Middle Columbia River Steelhead DPS Recovery Plan. As implementation proceeds and implementation schedules are developed, the costs of both existing programs and new incremental costs of this recovery plan will be included in those schedules. If existing

programs are not funded, funding will be identified as a need in the implementation schedule and the cost estimates for the recovery plan adjusted accordingly.

In this chapter, cost estimates are provided for an extensive and reach-specific set of potential habitat actions that will be refined and prioritized in the implementation process. NMFS, in coordination with the Yakama Nation, developed these cost estimates for a range of habitat improvement/restoration actions that may be necessary to address limiting factors and improve viability of the Rock Creek steelhead population. These costs, presented in Table 7-1 (in Chapter 7), are general range summaries. Habitat action costs for recovery over a 10-year time period are estimated to be up to $1.8 million ($0.9 million for years 1-5). The actions listed in Table 7-1 do not include or account for RM&E (Section 6.1.1), because those costs will be developed as part of implementation planning, nor do they account for tributary fishery harvest management and enforcement activities (Section 6.1.4), which are considered existing programs, nor for costs of out-of-subbasin effects, which are addressed through other programs (Section 6.1.6).

RM&E and Adaptive Management Framework

Comprehensive, empirical monitoring data on fish populations and habitat are needed to identify appropriate projects and locations, populate habitat/production capacity modeling efforts (such as EDT, AHA, or other appropriate models), and inform adaptive management for the salmonid recovery plan. Information on fish distribution, abundance, productivity, habitat conditions, genetic diversity, pathogen levels, and other population parameters, as well as on population limiting factors, is necessary to help direct and evaluate these efforts. A coordinated monitoring program is needed to ensure that these various needs, including salmonid recovery planning, are met.

As part of implementing the Rock Creek steelhead recovery plan, a detailed monitoring and evaluation program will be collaboratively designed and incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS' guidance document, Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance (NMFS 2007a) http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf. The Rock Creek subbasin monitoring and evaluation program will build on existing programs designed for monitoring tributary habitat in the Rock Creek subbasin and will emphasize regional coordination.

1. Introduction

The Endangered Species Act of 1973 (ESA) requires NOAA's National Marine Fisheries Service (NMFS) to develop recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA.

This plan focuses on the conservation and survival of Middle Columbia River steelhead (*Oncorhynchus mykiss*) in the Rock Creek subbasin, which encompasses an area of 223.2 sq. miles (578.1 sq. km) in southeastern Washington and joins the Columbia River at RM 230, about 12 miles upstream of John Day Dam (Figure 1-1). Lake Umatilla, the reservoir behind the dam, inundates the lower mile of Rock Creek.

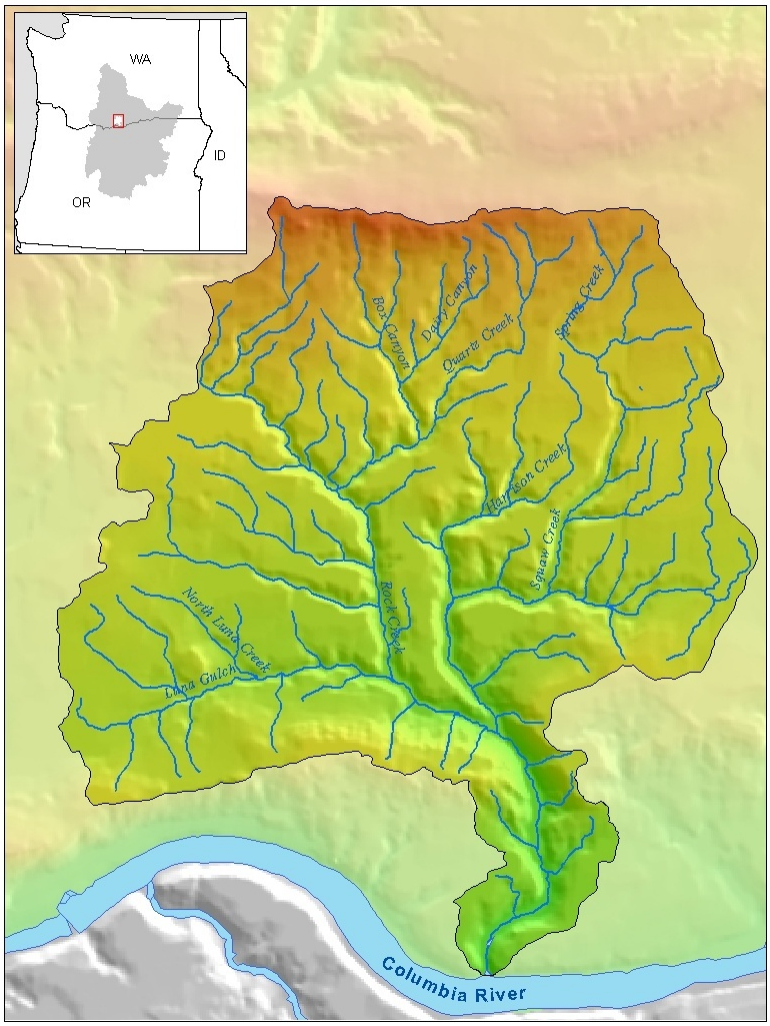


Figure 1-1 Rock Creek Subbasin.

"Steelhead" is the name commonly applied to the anadromous form of the biological species Oncorhynchus mykiss. The common name of the non-anadromous, or resident, form is rainbow trout. When NMFS originally listed the species as threatened on March 25, 1999 (64 FR 14517), it was classified as an "evolutionarily significant unit" (ESU) of salmonids that included both forms. Recently, NMFS revised its species determinations for West Coast steelhead under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS) (Good et al. 2005). NMFS listed the Middle Columbia River steelhead DPS as threatened on January 5, 2006 (71 FR 834). Rainbow trout are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). The DPS is made up of steelhead populations in Oregon and Washington tributaries of the Columbia River upstream of the Hood and Wind River systems, up to and including the Yakima River. Reasons for listing the Middle Columbia River steelhead DPS included low returns to the Yakima River, poor abundance estimates for Klickitat River and Fifteenmile Creek winter steelhead, and an overall decline of naturally producing "stocks" within the DPS.

NMFS developed this recovery plan with involvement and input from the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal agencies, state agencies, local governments, and the public. While NMFS is directly responsible for ESA recovery planning for salmon and steelhead, NMFS believes that ESA recovery plans for salmon and steelhead should be based on the many state, regional, tribal, local, and private conservation efforts already underway throughout the region. Local support of recovery plans by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential. NMFS therefore supports and participates in locally led collaborative efforts to develop recovery plans that involve local communities, state, tribal, and Federal entities, and other stakeholders.

1.1 Purpose of Plan

This Plan provides a roadmap for restoring the Rock Creek steelhead population and its habitats to a level that supports recovery of the Middle Columbia River steelhead DPS and allows the population to become a viable component of its ecosystem. The Plan is a guidance document. It describes the current status of the Rock Creek population and its habitat, and summarizes the results of a technical assessment of the population's viability. The Plan also identifies the factors and threats potentially affecting the population and proposes strategies and actions designed to aid in the population's recovery. Finally, the Plan provides an implementation and adaptive management framework for making needed future adjustments on the road to recovery.

1.1.1 ESA Requirements

Section 4(f) of the ESA requires that a recovery plan be developed and implemented for species listed as endangered or threatened under the statute.

ESA section 4(a)(1) lists factors for re-classification or delisting that are to be addressed in recovery plans:

A. The present or threatened destruction, modification, or curtailment of [the species'] habitat or range
B. Over-utilization for commercial, recreational, scientific or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting its continued existence

ESA section 4(f)(1)(B) directs that recovery plans, to the extent practicable, incorporate:

1. a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
2. objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this chapter, that the species be removed from the list; and;
3. estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

In addition, it is important for recovery plans to provide the public and decision makers with a clear understanding of the goals and strategies needed to recover a listed species and the science underlying those conclusions (NMFS Interim Recovery Planning Guidance, 2007).

Once a species is deemed recovered and therefore removed from a listed status, section 4(g) of the ESA requires the monitoring of the species for a period of not less than five years to ensure that it retains its recovered status.

1.1.2 Coordination with Others

The Plan aims to provide consistency among related recovery planning and management efforts, including NMFS' Federal treaty and trust responsibilities and the many state and local entities involved in salmon recovery.

Federal Treaty and Trust Responsibilities

Northwest Indian tribes have legally enforceable rights reserving to them a share of the harvestable salmon and steelhead. Achieving the basic purposes of the ESA such that the species no longer needs the protection of the Act may not by itself fully meet these rights and expectations, although it will lead to major improvements in the current situation. Ensuring a sufficient abundance of salmon to sustain harvest can be an important element in fulfilling trust and treaty rights as well as garnering public support for these plans.

It is NMFS policy that recovery of salmonid populations must achieve two goals: (1) the recovery and delisting of salmonids listed under the provisions of the ESA, and (2) the restoration of the meaningful exercise of tribal fishing rights. "It is the agency's view that there is no conflict between the statutory goals of the ESA and Federal trust responsibility to Indian tribes" (Letter from Terry Garcia, Assistant Secretary for Oceans and

Atmosphere, to Ted Strong, Executive Director, Columbia Inter-Tribal Fish Commission, July 21, 1998). Additionally, NMFS "will continue to join with states and tribes to develop a comprehensive approach to the restoration of fish and wildlife resources in a manner that fulfills all obligations under Federal law, including trust obligations to Indian tribes" (ibid.).

Thus, it is appropriate for recovery plans to take these considerations into account and plan for a recovery strategy that includes harvest. In some cases, the desired abundances for harvest may come about through increases in the naturally spawning population. In others, the recovery strategy may include appropriate use of hatcheries to support a portion of the harvest. So long as the overall plan is likely to achieve the biological recovery of the listed ESU, it will be acceptable as a recovery plan.

Treaty Indian fishing rights in the Columbia basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *United States v. Oregon*, No. 68-513 (filed in 1968). The parties to *U.S. v. Oregon* are the United States acting through the Department of Interior (USFWS and Bureau of Indian Affairs) and Department of Commerce (National Marine Fisheries Service), the Warm Springs, Umatilla, Nez Perce, Yakama, and Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho. In *U.S. v. Oregon*, the Court affirmed that the treaties reserved for the tribes 50 percent of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas.

The Rock Creek subbasin is part of the Yakama Nation's ceded area, and home to the Rock Creek Band of the Confederated Bands and Tribes of the Yakama Nation. Yakama Nation staff developed much of the data on the Rock Creek population. The Yakama Nation is voluntarily participating in recovery planning and implementation in the Rock Creek subbasin and throughout its ceded area as a sovereign with treaty-reserved rights on and off the reservation, and as a fish and wildlife co-manager. In so doing, Yakama Nation does not waive or in any way alter its treaty-reserved rights.

Other Federal, State and Local Responsibilities

To ensure consistency in goals, strategies, and actions and to eliminate needless duplication of effort, the process aims to provide consistency between planning for ESA recovery, the Northwest Power and Conservation Council (NPCC) fish and wildlife program, the State of Washington watershed management and salmon recovery programs, and local planning and regulatory efforts.

The Plan follows ESA guidelines and builds upon direction for Rock Creek in the Lower Mid-Columbia Mainstem Subbasin Plan (NPCC 2004), which included information provided by Yakama Nation, Washington Department of Fish and Wildlife, and other Federal, state, and local entities. The NPCC adopted the subbasin plan into its Fish and Wildlife Program. Additional scientific data are drawn from other more recent sources, including technical products for WRIA 31 and those developed by the technical recovery team appointed by NMFS for the Interior Columbia recovery domain.

1.2 Context of Plan Development

Currently there are 19 ESA-listed ESUs /DPSs of Pacific salmon and steelhead in the Pacific Northwest. For the purpose of recovery planning for these species, NMFS Northwest Region designated five geographically based "recovery domains": Interior Columbia; Willamette-Lower Columbia; Puget Sound and Washington Coast; the Oregon Coast; and the Southern Oregon/Northern California Coast. The range of the Middle Columbia River steelhead DPS is located in the Middle Columbia sub-domain of the Interior Columbia domain (the other Interior Columbia sub-domains are the Snake River and Upper Columbia). Similar opportunities for technical and stakeholder involvement exist in each domain.

1.2.1 Technical Recovery Teams

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each Technical Recovery Team (TRT) is to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. The Interior Columbia TRT (ICTRT) included biologists from NMFS, states, tribes, and academic institutions.

All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population viability criteria – criteria to be used, along with criteria based on mitigation of the factors for decline, to determine whether a species has recovered sufficiently to be downlisted or delisted. These principles are described in a NMFS technical memorandum, Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units (McElhany et al. 2000). Viable salmonid populations (VSP) are defined in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework, based on data availability, the unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective experience and expertise. Although NMFS encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs worked from a common scientific foundation.

1.2.2 Planning Forums

In each domain, NMFS has worked with state, tribal, local and other Federal entities to develop planning forums that build to the extent possible on ongoing, locally led recovery efforts. NMFS defined "management units" based on jurisdictional boundaries as well as areas where citizen planning efforts were underway. The Mid-Columbia management units are (1) Oregon; (2) Washington Gorge, which, in turn, is subdivided into three planning areas, White Salmon, Klickitat, and Rock Creek; (3) Yakima subbasin; and (4) Southeast Washington. These management units have active planning and implementation forums, with the exception of the Washington Gorge Management.

In the Washington Gorge Management Unit, NMFS has worked independently with the Yakama Nation, Washington Department of Fish and Wildlife (WDFW), Klickitat County, and local entities to develop the recovery plan for the Rock Creek steelhead population. NMFS encourages the formation of a planning forum for the Washington Gorge Management Unit.

Several small tributaries to the Columbia River drain areas in eastern Washington State upstream of Rock Creek. These tributaries are included in the Washington Gorge Management Unit. There is evidence of steelhead spawning in some of them, but very little data are available. Appendix I summarizes the available information about these tributaries as it relates to recovery of Middle Columbia steelhead. NMFS considers investigating these areas lower priority than restoring the core populations of the DPS, but includes a description of the areas because they are in the management unit and may be of interest to scientists and stakeholders at some future date.

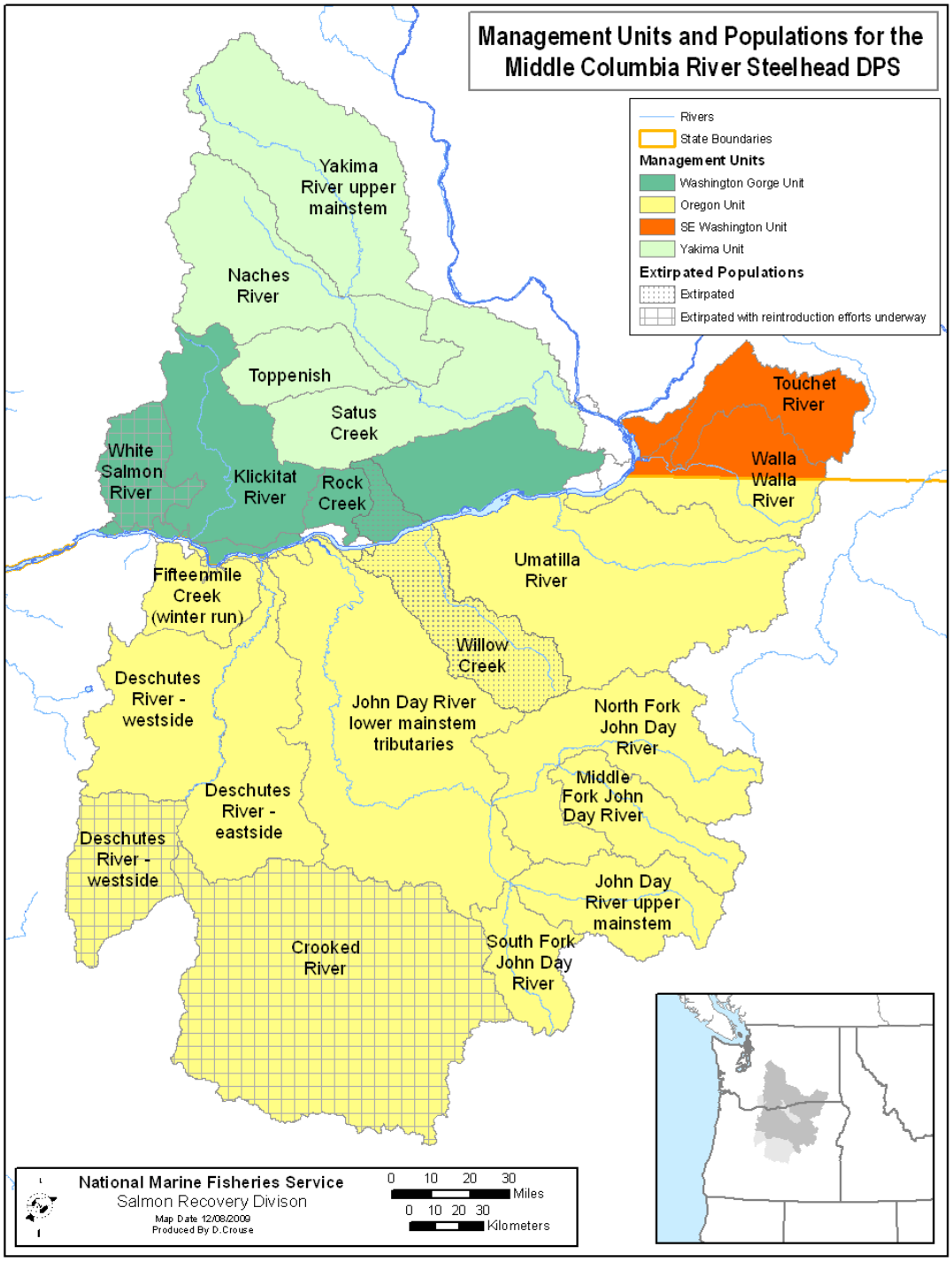


Figure 1-2 NMFS Management Units for the Middle Columbia Steelhead DPS.

1.3 How NMFS Intends to Use this Plan

Although recovery plans are not regulatory and their implementation is voluntary, they are important tools that help to do the following:

- Provide context for regulatory decisions.
- Guide decision making by Federal, state, Tribal, and local jurisdictions.
- Provide criteria for status reporting and delisting decisions.
- Organize, prioritize, and sequence recovery actions.
- Organize research, monitoring, and evaluation efforts.

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions carried out to meet section 7(a)(1) obligations to use their programs in furtherance of the purposes of the ESA and to carry out programs for the conservation of threatened and endangered species
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10
- Hatchery and Genetic Management Plans and permit requests
- Harvest plans and permits
- Selection and prioritization of subbasin planning actions
- Development of research, monitoring, and evaluation programs
- Revision of land use and resource management plans
- Other natural resource decisions at the state, Tribal, and local levels

NMFS will emphasize recovery plan information in ESA section 7(a)(2) consultations, section 10 permit development, and application of the section 4(d) rule by considering:

- The importance of affected populations to listed species viability
- The importance of the action area to affected populations and species viability
- The relation of the action to recovery strategies and management actions
- The relation of the action to the research, monitoring, and evaluation plan for the affected species

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. NMFS staff will encourage the Federal "action agencies" to describe in their biological assessments how, within the action area, their proposed actions will affect individuals of specific populations and limiting factors identified in the recovery plans, and to describe any mitigating measures and voluntary recovery activities in the action area.

2. Biological Background

This chapter describes habitat and population characteristics for Middle Columbia River steelhead in the Rock Creek subbasin, and also fills in some important background on salmonid biological structure.

2.1 Physical Setting

Rock Creek joins the Columbia River at RM 230, about 12 miles upstream of John Day Dam. The watershed encompasses an area of 223.2 sq. miles (578.1 sq. km). Lake Umatilla, the reservoir behind the dam, inundates the lower mile of Rock Creek. Headwater tributaries of Rock Creek flow out of the Simcoe Mountains, which form the subbasin's northern border and the southern edge of the Yakama Indian Reservation. Major tributaries to Rock Creek include Badger Gulch, Harrison Creek, Luna Gulch, Quartz Creek, White Creek and Squaw Creek (Figure 2-1).



Figure 2-1. Geology and Stream Location of Rock Creek Subbasin (Aspect Consulting and WPN 2004).

The entirety of the Rock Creek subbasin is located within Klickitat County, and the subbasin's population, as of the 2000 census, was 503 persons. It is also part of the area the Yakama Nation ceded to the United States in the Treaty of 1855, while reserving fishing, hunting and gathering rights, among other rights and responsibilities. In the lower and eastern portions of the watershed, the Yakama Nation and its members own a significant amount of trust allotments.

Lands in the Rock Creek subbasin remain largely undeveloped, with nearly 47 percent rangeland, 26 percent forestland, and 4 percent dry land agriculture (Figure 2-2). Most forestland exists at upper elevations; range and agricultural lands generally cover the middle and lower watershed. No irrigated land was estimated to exist as of 2001 (Aspect Consulting and WPN 2004). Developed land accounts for less than one percent of the subbasin area (Aspect Consulting and WPN 2004), little of which is in the floodplain (http://klickitatcounty.org/Road/ContentROne.asp?fContentIdSelected=455695186&fCategoryIdSelected=948111261). Deeply incised canyons with narrow valley floors make up most of the upper portions of the fish-bearing tributaries.

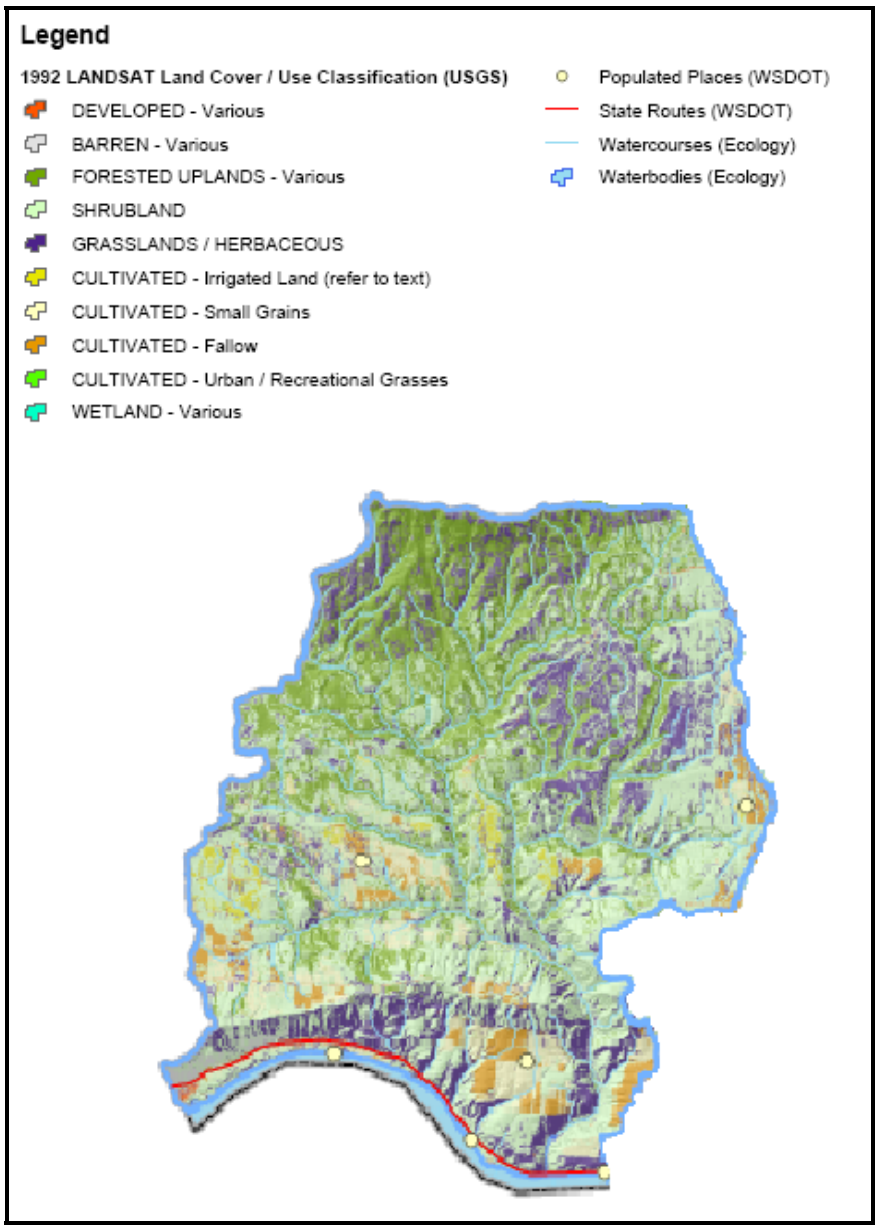


Figure 2-2. Land Use in the Rock Creek subbasin (Adapted from Aspect Consulting and WPN 2004).

2.1.1 Topography

The Rock Creek drainage has a steep topography; approximately 20 percent of the area has side slopes greater than 100 percent (Aspect Consulting and WPN 2004). This is reflected in the subbasin's great stream velocities and erosion potential. The underlying basalt geology also creates several potential barriers to upstream movement of adult anadromous fish, including partial barriers on Quartz Creek (RM 2.4) and upper mainstem Rock Creek (RM 19.4, RM 20.7, RM 22.7), as well as barriers on the upper Rock Creek mainstem (RM 23.1). A falls in Box Canyon (RM 0.3) is likely the only currently impassable barrier under most flow conditions (Greg Morris, pers. comm. 2006). No complete barriers (natural or manmade) to steelhead passage were identified

during a habitat survey conducted in 2008 within the area delineated as steelhead distribution (Glass 2009); however, not all of the area was surveyed, and barriers could exist in the unsurveyed portions of the basin. The average Rock Creek basin elevation is 2,162 feet (maximum 4,728 feet, minimum 266 feet) (Aspect Consulting and WPN 2004).

Streams in the Rock Creek subbasin share many similar geomorphic characteristics. From the headwaters, the streams cross a relatively flat basalt plateau at gradients of generally less than 1 percent. Headwater and plateau areas are primarily forested and presumed to be above most anadromous use. Coming off the plateau, streams enter steep-walled canyons where gradients increase to 2-4 percent or more, and substrates consist of gravel, cobbles, and boulders. Although limited by narrow floodplains, riparian vegetation in the canyon reaches is often of relatively good quality (Glass 2009). Suitable spawning gravel and rearing areas (pools) are intermittent and limited by geomorphic conditions. Downstream of the canyon reaches, streams flow through alluvial valleys that support agriculture and range uses. Gradients in these reaches generally drop from between 1 percent and 2 percent near the upper end to less than 1 percent as streams approach the Columbia River (Lautz 2000).

In several reaches of the lower river, large quantities of rock have been deposited where the grade breaks (Glass 2009). Through these avulsed areas, the channel is not well defined and often changes course during major flood events. The riparian vegetation along the creek in the avulsed area is sparse, largely due to the naturally unstable condition of the channel in those reaches. In the rest of the lower Rock Creek basin, riparian vegetation is highly variable (Aspect Consulting 2005). Substrate in alluvial reaches is dominated by gravel and cobble (Glass 2009).

2.1.2 Hydrology

Average annual precipitation in Rock Creek is 16.2 inches (Aspect Consulting and WPN 2004). Flows in the subbasin's canyon and alluvial reaches are considered flashy, rising and falling rapidly in response to precipitation and snowmelt. Snowmelt runoff from higher elevations appears to help sustain flows into early spring. Aspect Consulting and WPN 2004 report that the streams have eroded into and dissected the underlying basalt unit, which has resulted in truncated basalt interflow zones, such that the aquifer units are discontinuous and disconnected from recharge sources. The water flowing in these discontinuous aquifer zones discharges along seepage faces in the canyons (Aspect Consulting and WPN 2004). Numerous springs in the subbasin also discharge groundwater through the incised underlying basalt. These springwater releases may provide important cool water refuges for juvenile salmonids during the summer and early fall when stream flows are at their lowest and stream temperatures are high (NPCC 2004). The releases, however, are generally insufficient to sustain continuous stream flows in the lower subbasin during the dry season (Aspect Consulting and WPN 2004). No flow regulation occurs in the drainage, although small amounts of water are diverted for stock watering.

Stream flow data are very limited for the subbasin and consist of historical information (presence or absence of flow) collected by the General Land Office in the 1860s (reported in Aspect Consulting and WPN 2004), USGS recorded flows from 1962 to 1968, incomplete staff gauge data being collected by the Yakama Nation since 2005, a continuous flow gauge operated by the Washington Department of Ecology since November 2007 (https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?wria=31), and spot measurements of flow taken by Eastern Klickitat Conservation District since 1995 (data for years 1995 to 2003 reported in Aspect Consulting and WPN 2004).

Flows in Rock Creek are typically seasonal, with no measured surface flow at the monitoring station in the summer months (Figure 2-3). The exception in the period of record is the summer of 1965, when flows were maintained as a result of an exceptionally wet winter and spring (Figure 2-4). Monthly median (50 percent exceedance) and low (90 percent exceedance) during August, September, and October are zero cfs (Figure 2-5; Aspect Consulting and WPN 2004). Pools are abundant in the basin even when stream flow is apparently zero. In late fall of 2008, no flow was apparent at the Department of Ecology flow gauge, yet at least 4,229 cubic meters of pool habitat were present. Pool volume in the reach inundated by Lake Umatilla and reaches on Tribal Trust lands were not included in the estimate (Glass 2009).

Historical information, coupled with observed intermittent conditions based on USGS stream gauge data in the 1960s, suggest that the streamflow in Rock Creek is naturally intermittent rather than a condition created by human development (Aspect Consulting and WPN 2004). Much of the runoff generally occurs in two or three discrete events (Figure 2-5). For example, in water year 2008-2009, much of the total runoff occurred during two major events in December, and the balance occurred at much lower levels in spring.

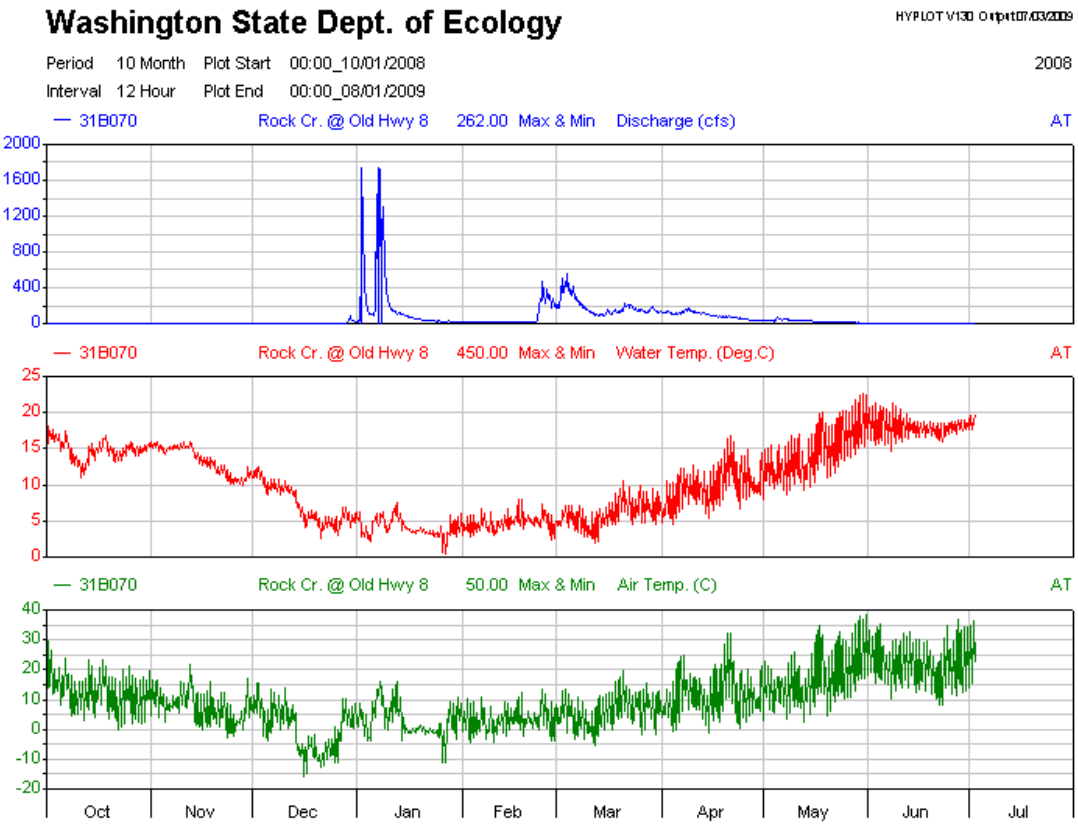


Figure 2-3. Stream flow, water temperature, and air temperature at the Washington Department of Ecology gage near the mouth of the Rock Creek. from October, 2008 to June 2009 (https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=31B070).

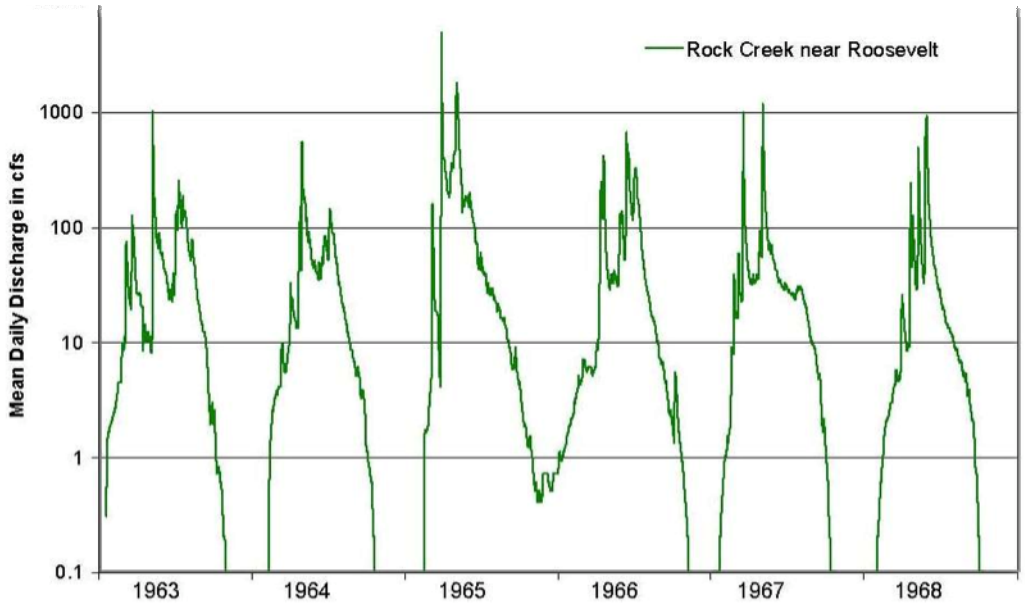


Figure 2-4. Discharge Hydrograph from Historical USGS flow Gauge near Mouth of Rock Creek. (Aspect Consulting and WPN 2004).

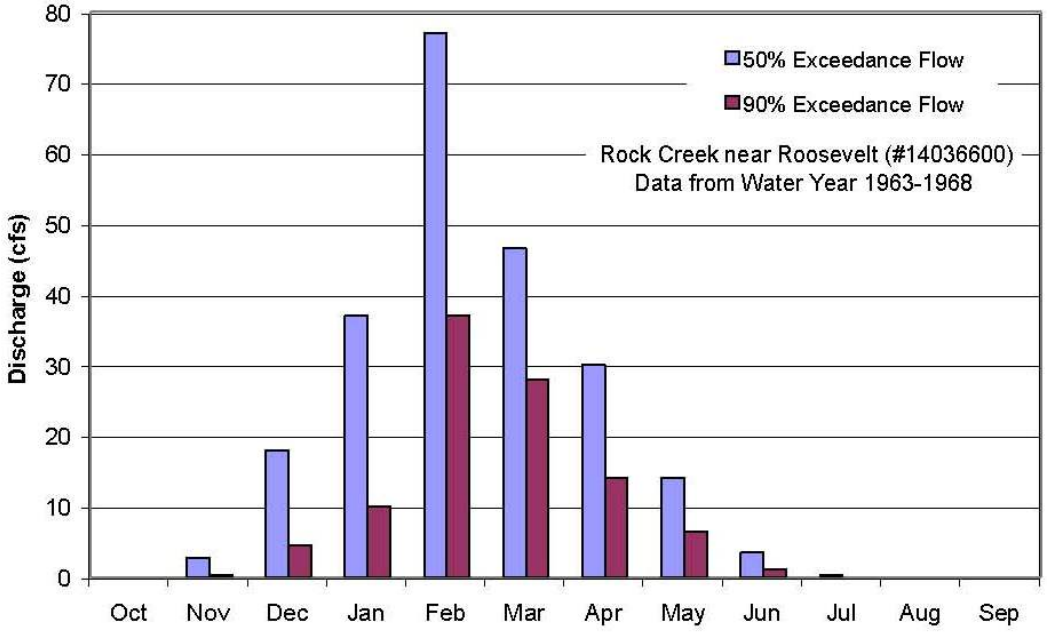


Figure 2-5. Monthly Exceedance Flows for Historical USGS Flow Gage near Mouth of Rock Creek. (Aspect Consulting and WPN 2004).

2.1.3 Water Quality

One headwater reach of Rock Creek is listed for temperature on the Washington Department of Ecology's (Ecology) 2008 water quality assessment list (often referred to as the "303(d) list") as Category 5, a water body that requires a TMDL (Ecology 2008). This headwater reach of Rock Creek was changed from Category 4B (designation for water bodies that have a pollution control program) to Category 5 on 3/24/05 because Ecology had not been able to confirm the results of implementation of items contained within the Memorandum of Agreement (MOA) between Ecology and the Eastern Klickitat Conservation District (EKCD) (http://apps.ecy.wa.gov/wats08/ViewListing.aspx?LISTING_ID=7967).

While only one reach in Rock Creek Basin is designated Category 5, published data suggest that many areas in Rock Creek and some of its tributaries (i.e., Quartz Creek, Squaw Creek, and Luna Gulch) frequently exceeded the applicable temperature criterion (7-DADMax of 17.5°C [63.5° F]) over the period of 1995 to 2004 (Aspect 2005) (Figure 2-6). A supplemental temperature standard (7-DADMax 13°C (55.4°F) for salmonid spawning and incubation is applicable to some areas of Rock Creek and several of its tributaries from February 1 to June 1 (http://www.ecy.wa.gov/pubs/0610038/start.pdf). Conformance with this supplemental standard has not been assessed, but available data suggest that it is exceeded in many areas of Rock Creek (Figure 2-6).

Approximately 73 percent of all O. mykiss observed in the basin during the single pass snorkel surveys conducted in late fall 2008 were found in the mainstem of Rock Creek between water temperature monitoring stations identified in Figure 2-6 as RC-09 and RC-06 (Glass 2009).

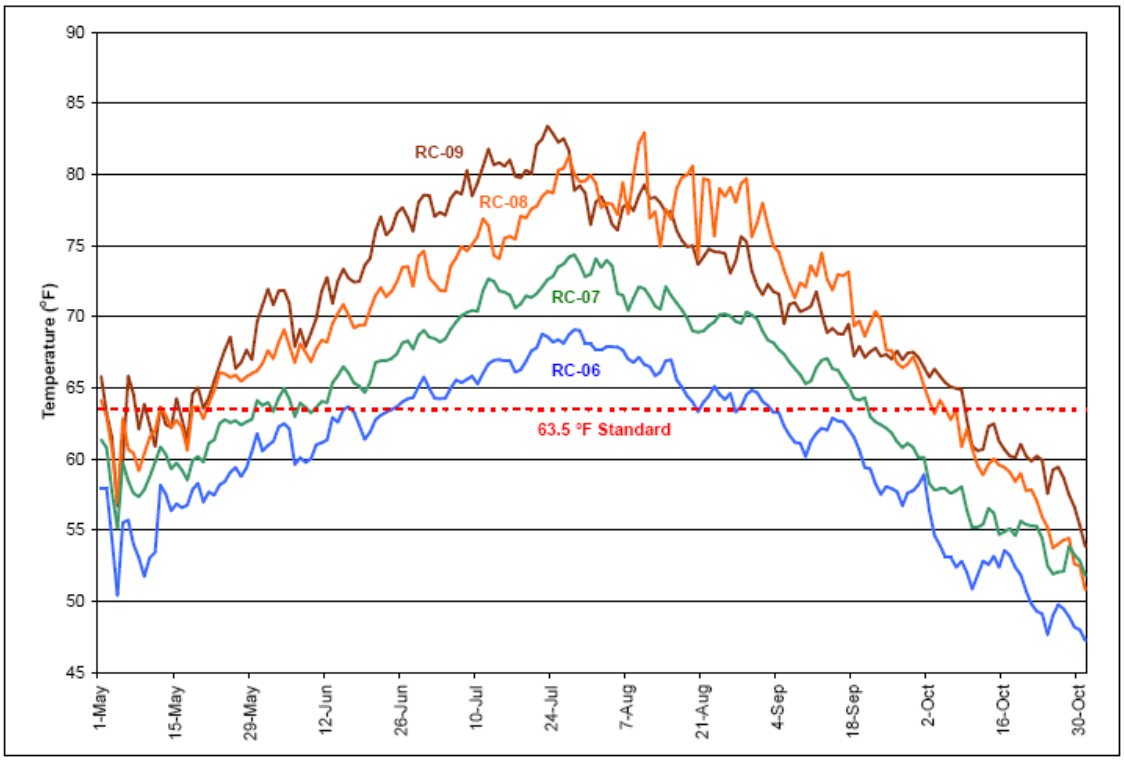


Figure 2-6. Daily maximum water temperature at four stations in Rock Creek based on 1999 to 2004 data (Aspect 2005). (RC-09 is located near the mouth of Rock Creek, RC-8 is located just downstream of the confluence with Squaw Creek, RC-7 is located in Squaw Creek near the confluence with the mainstem Rock Creek, and RC-6 is located upstream in the basin near the confluence with Badger Gulch.)

In 1995-1996, Ecology, in cooperation with the EKCD and the Natural Resources Conservation Service (NRCS), completed an evaluation of water temperature, including the influence of riparian canopy cover, on Rock Creek (Ehinger 1996). For the study, EKCD and the NRCS deployed continuous water temperature loggers at ten stations within Rock Creek during summer 1995. They also conducted a stream habitat evaluation at each station. During the study period, the loggers recorded daily maximum stream temperatures above the current default water temperature standard of 63.5°F (17.5°C) throughout the 1995 summer months at most stations monitored (Aspect Consulting and WPN 2004). In addition, stream habitat evaluation results showed that six of the ten stations had riparian canopy (vegetative) cover more than 10 percent below state target goals for eastern Washington Class A streams (Aspect Consulting and WPN 2004).

However, an analysis of historical aerial photographs revealed that the aerial extent of vegetation in the valley bottom of the mainstem of Rock Creek (lower 15 miles of the creek, excluding the area inundated by Lake Umatilla) increased 10 percent between 1996 and 2002, presumably due to fire exclusion (Aspect 2005). Ehinger (1996) inferred that the high water temperatures in upper Rock Creek "may be natural for a small creek in a hot, sunny summer climate." It was inferred that the lack of riparian shading and

rocky substrate contribute to elevated water temperatures in the lower stream reaches (Aspect Consulting and WPN 2004).

Aspect Consulting (2005) arrived at much the same conclusion in an assessment of water temperature in Rock Creek conducted for the WRIA 31 Planning Unit. Namely, "*The Rock Creek subbasin is sparsely populated with minimal water use, and geological conditions limit the quantities of groundwater discharge (springs) to support summer stream flows. This lack of late-season baseflow, in conjunction with the braided and highly dynamic stream channel and limited riparian vegetation in the lower reaches, combine to create a situation in which the water that is present is subject to abundant solar heating, and thus elevated water temperatures, throughout the summer. In this case, ongoing water temperature monitoring by EKCD is serving to establish a baseline condition for the watershed. Although it is difficult to definitively attribute the observed high water temperatures to natural causes versus anthropogenic causes, we are not aware of any evidence indicating it is the result of anthropogenic causes*" (Aspect 2005).

2.2 Life History Characteristics

Based on their level of sexual maturity at the time they enter freshwater and the duration of the spawning migration, steelhead populations in the Mid-Columbia DPS can be classified into one of three major life history patterns: summer run, winter run or a summer/winter run arrangement (ICTRT 2009). All steelhead in the Columbia River Basin upstream of The Dalles Dam, including the Rock Creek population, are classified as summer-run fish (Chapman et al. 1994; ICTRT 2009); however, Yakama Nation biologists suspect that a portion of the steelhead population in Rock Creek consists of winter-run fish.

Generally, winter-run fish enter freshwater streams between November and April, while summer-run fish enter rivers between May and October. Summer steelhead are of the stream-maturing type and enter freshwater in a sexually immature condition, requiring several months in freshwater to mature and spawn. Winter steelhead mature in the ocean and enter freshwater with well-developed gonads and spawn relatively shortly after river entry (Bambrick et al. 2004).

A combination of environmental cues, including flow and temperature, triggers spawn timing throughout the Rock Creek watershed. Spawning begins in the middle of March and peaks in early April. Upper watershed steelhead appear to spawn about three weeks later. Steelhead generally spawn in clear, cool streams with suitable gravel size, depth and flow velocity (Bjornn and Reiser 1991).

The range of temperatures steelhead can tolerate varies with life stage and other characteristics. Temperatures above 13.3ºC (56ºF) can result in egg mortality (McEwan and Jackson 1996), and sufficient oxygen may not be available above 21.1ºC (70ºF) (ibid.). Steelhead are considered to do best at a range of 12.8-15.6º C (55.0-60.1º F) (Rich 1987). Temperatures above 22^{o} C (72^{o} F) are highly stressful for steelhead.

Data regarding the average age, sex ratio, etc. of steelhead spawners in Rock Creek are unavailable. Further research is needed. Spawners include an unknown number of kelts (repeat spawners). Some steelhead are *iteroparous* (do not die after spawning), and may return to the ocean for a short period and repeat the spawning migration, a life history adaptation that may be fundamental to ensuring population stability. Respawning rates may be affected by environmental conditions, location of the natal stream, sex, size at maturity, and differences in the energy investment of spawning among different stocks and species (Fleming 1998). Reduced genetic contributions from populations formerly supplemented by repeat spawners may contribute to the decline of steelhead stocks in the Columbia River basin (NMFS 2000).

Iteroparity for Mid-Columbia steelhead ranges from reported rates of 2-4 percent above McNary Dam (at RM 292 measured from the mouth of the Columbia) (Busby et al. 1996) to 17 percent in the unimpounded tributaries below Bonneville Dam (at RM 146.1) (Leider et al. 1986). Iteroparity rates for Rock Creek River steelhead are unknown.

Steelhead eggs incubate at the same time that temperatures are increasing. In the lower mainstem Rock Creek where densities are highest, fry emerge very rapidly. Densities from electro-shocking suggest that emergence occurs in approximately 60 days (NPCC 2004). Because the lower mainstem becomes intermittent from July to late October, juvenile steelhead in the reach must use a number of life history strategies. While juveniles likely continue to rear in upper watershed areas during these months, juveniles reared in the lower watershed may either move out of the system, take advantage of pools, risking encounter with smallmouth bass and other predators in the lower 3.5-4.0 miles, or move higher in the watershed (NPCC 2004). No predators were observed during snorkel surveys conducted in mid-October/early-November 2008 above the area inundated by Lake Umatilla excluding reaches on Tribal Trust lands (Glass 2009). Approximately 94 percent of the juveniles observed in the Rock Creek mainstem during these snorkel surveys were in the lower sections of the river, downstream of the Bickleton Bridge, suggesting that few, if any, move upstream to rear (Glass 2009). It is unknown if juveniles rearing anywhere in the watershed move into the Columbia River to rear.

While limited information exists on steelhead abundance in the Rock Creek drainage, some observations suggest that a significant number of steelhead may use the Rock Creek watershed in years of good water and ocean conditions. Surveys conducted by the Yakama Nation in lower Rock Creek in 2002, 2003, and 2004 found as many as 35 to 45 steelhead redds per mile in the lower 5 miles, and extensive distribution of redds throughout the watershed (NPCC 2004). These surveys, however, were intermittent and were not conducted across all potential habitat. Spawner surveys conducted in April of 2009 found 20 redds and 6 additional features that might have been redds between the Bickleton Bridge and River Mile 4 (Glass 2009), the equivalent of roughly 2 redds per mile. Survey crews estimated that 30 to 40 percent of that area could not be adequately surveyed due to limitation on visibility, so the actual number of redds may have been 30 to 40 percent higher than reported. More surveys are needed to determine steelhead abundance and distribution in the drainage. Further research is needed.

Steelhead are believed historically to have utilized virtually all of the accessible major streams and tributaries of Rock Creek for some aspect of their life history. Spawning distribution probably included all accessible portions of the Rock Creek watershed. Then as now, the highest spawning densities likely occurred in the more complex, braided reaches of the lower mainstem of Rock Creek, and in third- and fourth-order tributaries with moderate (1-4 percent) gradients (NPCC 2004). The headwaters of the mainstem are generally above known anadromous fish use (NPCC 2004), although spawning has been observed up to the falls in Box Canyon (RM 0.3).

The current steelhead range in the Rock Creek watershed likely resembles the historical condition. During single pass snorkel surveys conducted in early October to mid-November 2008, no O. Mykiss were observed in the Rock Creek mainstem between the upper extent of the Lake Umatilla backwater and approximately RM 2, where the survey stopped because of private land ownership. The snorkel survey resumed at approximately RM 5. Approximately 78 percent of the O. mykiss observed in the Rock Creek subbasin were between RM 5 and the confluence with Quartz Creek and a few more fish (5 fish total) were observed upstream of Quartz Creek. O. mykiss were also observed in Squaw Creek to a point roughly 5 miles upstream of the confluence with White Creek. The majority of O. mykiss in Squaw Creek were found downstream of the confluence with Harrison Creek. No O. mykiss were observed in the lower reaches of Quartz Creek. Since anadromous and resident forms cannot be visually distinguished, the proportion of the O. mykiss observed in 2008 that were of anadromous form is unknown (Glass 2009).

Yakama Nation biologists observed live steelhead adults, redds, and *O. mykiss* fry in Rock Creek above the confluence of Quartz Creek; in Quartz Creek above the Box Canyon confluence; and in lower Box Canyon up to the falls at RM 0.3 (from the Quartz Cr. confluence). Live steelhead and redds have also been confirmed 0.5 RM up an unnamed tributary located below the confluence of Rock and Quartz creeks (RM 19.2). Additionally, steelhead adults and *O. mykiss* fry have been observed in Badger Gulch. Landowners report having seen steelhead adults, redds, and *O. mykiss* fry up Luna Gulch, from the confluence with Rock Creek, and into Squaw Creek, as well as catching steelhead in White and lower Harrison creeks (up to RM 2.5). Yakama Nation staff also noted 'anecdotal' evidence of steelhead being observed in mainstem Squaw Creek 2.0 miles upstream of the confluence with White Creek. In the Rock Creek mainstem, BLM staff recorded seeing steelhead above the confluence with Quartz Creek as well as in lower Quartz Creek (BLM 1985; BLM 1986). Figure 2-7 shows the current distribution of Rock Creek steelhead as observed by Yakama Nation biologists.

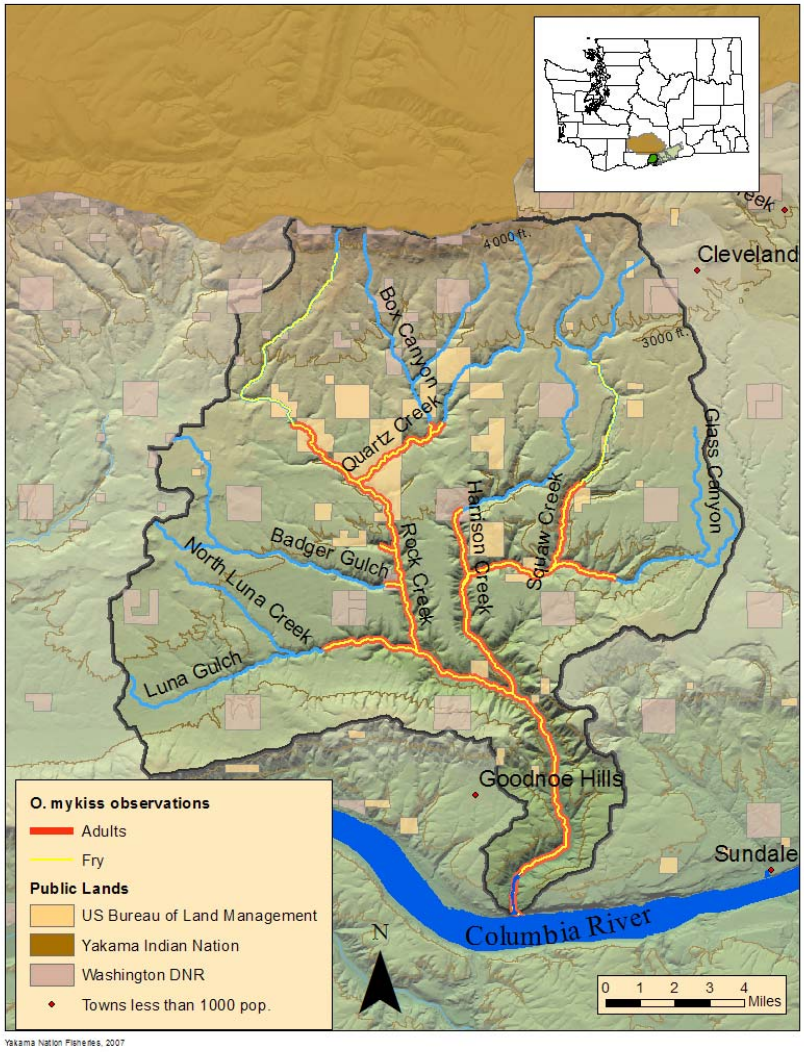


Figure 2-7. Rock Creek subbasin major streams and steelhead distribution as observed by Yakama Nation Fisheries Staff.

2.3 Major Spawning Area

The ICTRT identified potential intrinsic habitat in the Rock Creek subbasin as a major spawning aggregation (MaSA) for Middle Columbia River steelhead (Figure 2-8). The ICTRT delineated this MaSA using model results that estimated the historical amount of potentially accessible spawning and rearing habitat available to a specific population based on stream width, gradient, and valley width from GIS-based analysis of tributary habitat associated with each population (ICTRT 2005).

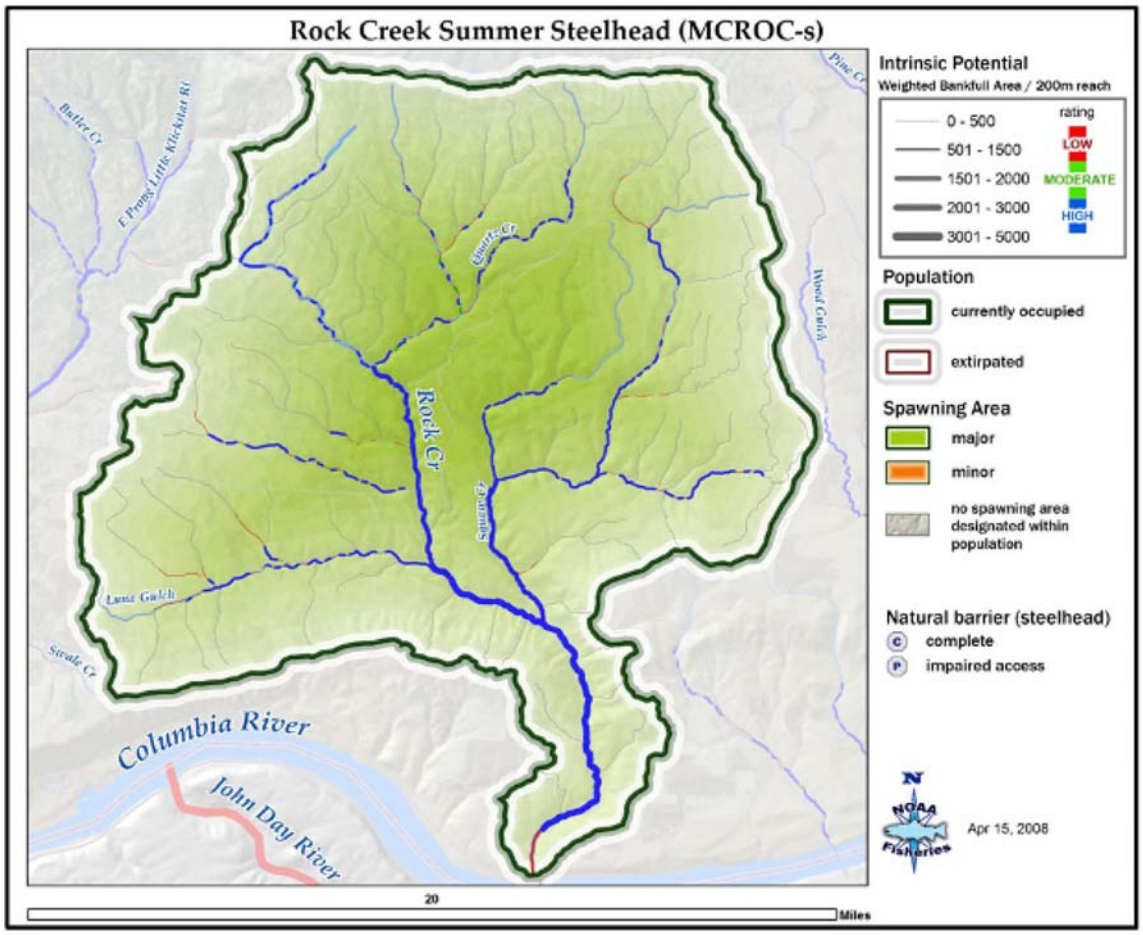


Figure 2-8. Rock Creek summer steelhead population boundary and major (MaSA) and minor (MiSA) spawning areas (ICTRT 2009).

2.4 Salmonid Biological Structure

Salmonid species' homing propensity (their tendency to return to the locations where they originated) creates unique patterns of genetic variation and connectivity that mirror the distribution of their spawning areas across the landscape. Diverse genetic, life history, and morphological characteristics have evolved over generations, creating runs highly adapted to diverse environments. It is this variation that gives the species as a whole the resilience to persist over time.

Historically, a salmon ESU or, as in this case, steelhead DPS typically contained multiple populations connected by some small degree of genetic exchange by straying spawners. Thus, the overall biological structure of the ESU/DPS is hierarchical; spawners in the same area of the same stream will share more characteristics than those in the next stream over. Fish whose natal streams are separated by hundreds of miles will have less genetic similarity. The ESU or DPS is a metapopulation defined by the common characteristics of populations within a geographic range. Recovery planning efforts focus on this biologically based hierarchy (Figure 2-9).

McElhany et al. (2000) formally identified two levels in this hierarchy for recovery planning purposes: the evolutionarily significant unit (ESU) or distinct population segment (DPS) and the independent population. The ICTRT identified an additional level between the population and ESU/DPS levels, which they call a major population group (MPG) (McClure et al. 2003).

2.4.1 Distinct Population Segments

An ESU or DPS is a distinctive group of Pacific salmon or steelhead that is uniquely adapted to a particular area or environment. Because of the hierarchical structure of salmonid populations, the concept of "distinctive group" has received considerable attention and refinement. An ESU is defined as a group of Pacific salmon that is "substantially reproductively isolated from other conspecific units and represents an important component of the evolutionary legacy of the species" (Waples 1991). A "population segment" is considered distinct (a DPS and hence, like ESUs, considered a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, or if it occupies an unusual or unique ecological setting, or if its loss would represent a significant gap in the species' range. ESUs/DPSs may contain multiple populations that are connected by some degree of migration, and hence may have a broad geographic range across watersheds and river basins.

2.4.2 Major Population Groups

Within an ESU/DPS, independent populations can be grouped into larger populations that share similar genetic, geographic, and/or habitat characteristics (McClure et al. 2003). These "major groupings" of populations (MPGs) are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between ESUs/DPSs. The relationship between ESU/DPS, MPG, and independent populations is depicted in Figure 2-9.

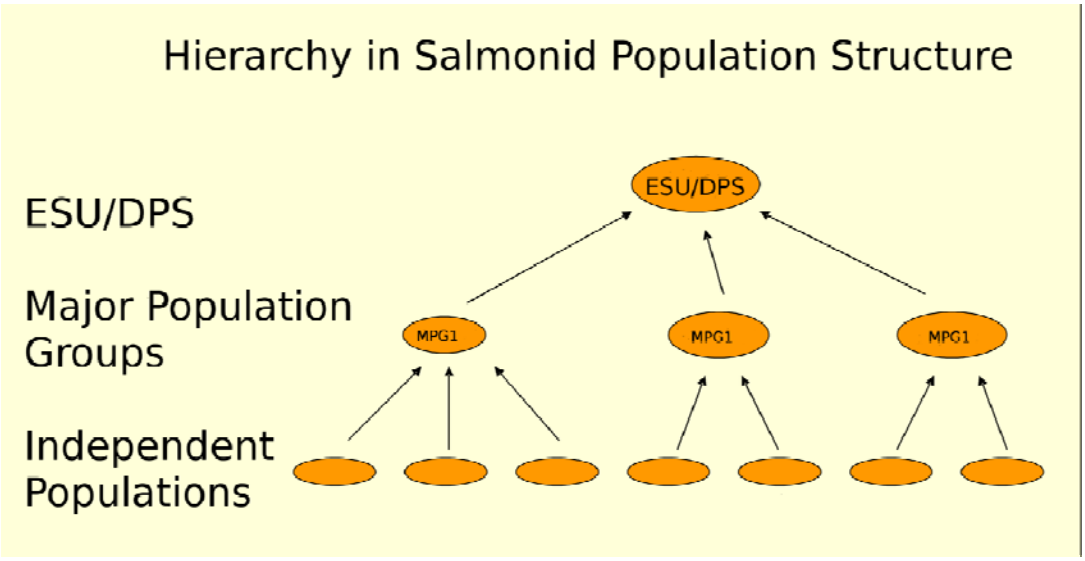


Figure 2-9 Hierarchical levels of salmonid species structure as defined by the TRTs for ESU/DPS recovery planning.

2.4.3 Independent Populations

McElhany et al. (2000) defined an independent population as follows:

"…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."

2.5 Middle Columbia Steelhead Populations and MPGs

The ICTRT identified 17 extant and 3 extirpated independent steelhead populations in the Middle Columbia River steelhead DPS (McClure et al. 2003). These populations are shown in Figure 2-10. The ICTRT delineated the populations based on genetic information, geography, life-history traits, morphological traits, and population dynamics.

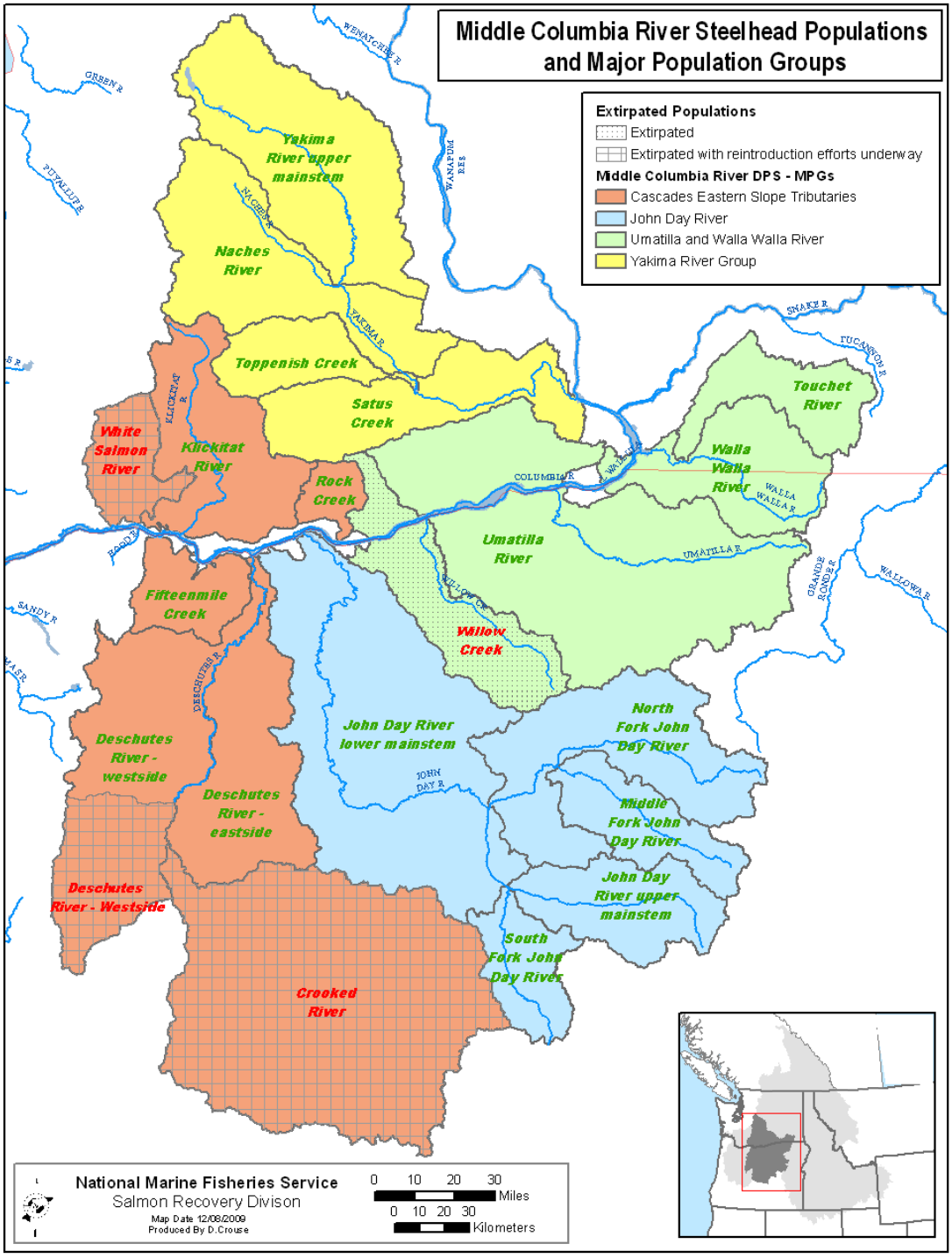


Figure 2-10 Middle Columbia River Steelhead Independent Populations and Major Population Groups.

The ICTRT grouped these independent populations into four major population groups (MPGs) within the DPS: the Cascades Eastern Slope Tributaries MPG, Yakima River

MPG, John Day River MPG, and Umatilla/Walla Walla MPG. The Rock Creek population is one of five extant populations (Klickitat River, Fifteenmile Creek, Rock Creek, Deschutes River Eastside, and Deschutes River Westside) and two extirpated populations (White Salmon River and Deschutes Crooked River) comprising the Cascades Eastern Slope Tributaries MPG (Figure 2-10). Populations in the group are united primarily by proximity and occupy diverse habitats, generally those draining the eastern slopes of the Cascades and the Columbia Plateau.

The ICTRT classified the Rock Creek population as Basic in size, based on intrinsic habitat potential (Table 2-1)

Table 2-1 Rock Creek Summer Steelhead Basin Statistics (ICTRT 2009).

Drainage area (km^2)	586
Stream lengths km (total) [a]	169
Stream lengths km (below natural barriers) [a]	166
Branched stream area weighted by intrinsic potential (km^2)	0.665
Branched stream area km^2 (weighted and temp. limited) [b]	0.411
Total stream area weighted by intrinsic potential (km^2)	0.683
Total stream area weighted by intrinsic potential (km^2) temp limited [b]	0.419
Size / Complexity category	Basic
Number of Major Spawning Areas (MaSAs)	1
Number of Minor Spawning Areas (MiSAs)	0

a. All stream segments greater than or equal to 3.8m bankfull width were included
b. Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22°C.

3. Recovery Goals and Delisting Criteria

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act – i.e. to be delisted. Recovery plans may also contain "broad-sense goals," defined in the recovery planning process, that go beyond the requirements for delisting to address, for example, other legislative mandates or social, economic, and ecological values.

Delisting criteria are applied at the DPS level, and are based on determinations of the viability of the independent populations that make up the DPS. Criteria for delisting the Middle Columbia steelhead DPS are described in the Middle Columbia Steelhead ESA Recovery Plan, to which this plan is an appendix. This chapter provides recovery goals for the Rock Creek steelhead population, describes the criteria to be used to assess progress toward those goals, and describes the role of the Rock Creek steelhead population in overall DPS viability.

There are two kinds of criteria that enter into a delisting decision: population, or demographic parameters (the biological recovery criteria) and "threats" criteria related to the five listing factors detailed in the ESA. The threats criteria define the conditions under which the listing factors, or threats, can be considered to be addressed or mitigated. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B) of the ESA. Both kinds of criteria are discussed in this chapter.

3.1 Recovery Goals

The primary goal of this plan is for the Rock Creek steelhead population to be restored to a sufficiently robust condition to support recovery of the Mid-Columbia steelhead DPS. If a local, collaborative Washington Gorge Area Regional Board is formed, it may choose to define broad-sense goals for the Rock Creek subbasin and other areas within the Washington Gorge Management Unit. The Board's broad-sense goals for the area would likely build upon direction from, and respond to interests identified by various stakeholders in the area. These goals would then guide the Board as it defines and implements future recovery actions for the Rock Creek subbasin.

For DPS delisting, the Rock Creek population should attain at least "moderate" risk status, also called "maintained" status by the ICTRT (described in more detail in Section 3.2.2). Achieving moderate risk status would be consistent with putting the population on a trajectory toward achieving viability. The ICTRT cautioned against closing off the options for any population prematurely, because of the many uncertainties in predicting the biological response to recovery actions (ICTRT 2007a).

3.2 Biological Viability Criteria

The ICTRT developed biologically based viability criteria for ESA-listed salmon and steelhead in the Interior Columbia domain. The ICTRT based its approach to recovery on guidance from the NMFS Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). This memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels. A viable population is defined as an independent population that has negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElhany et al. 2000).

Viability criteria at the population level address four VSP parameters (McElhany et al. 2000):

- *Abundance* – the average number of spawners in a population over a generation or more,
- *Productivity* – the performance of a population over time in terms of recruits produced per spawner,
- *Spatial Structure* – a population's geographic distribution and the processes that affect that distribution, and
- *Diversity* – the distribution of genetic, life history and phenotypic variation within and among populations.

The ICTRT grouped specific population level criteria into two categories to assess viability at the independent population level: measures addressing abundance and productivity, and measures addressing spatial structure and diversity. The viability of an independent population is determined by integrating risks across the four parameters. Additionally, the VSP guidelines (McElhany et al. 2000) recommend that a viable DPS population should be large enough to:

1. have a high probability of surviving variation observed in the past and expected future;
2. be resilient to environmental and anthropogenic disturbances;
3. maintain genetic diversity; and
4. support/provide ecosystem functions.

They also recommend that viable populations demonstrate sufficient productivity to support a net replacement rate of 1:1 or higher at abundance levels established as long-term targets. Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels.

3.2.1 DPS and MPG Viability Criteria

The major objectives of the ICTRT's viability criteria are to ensure preservation of basic historical metapopulation processes including 1) genetic exchange across populations within an ESU/DPS over a long time frame; 2) the opportunity for neighboring populations to serve as source areas in the event of local population extirpations; 3) population distribution within an ESU/DPS so that they are not all susceptible to a specific localized catastrophic event (ICTRT 2007b).

Since MPGs are geographically and genetically cohesive groups of populations, they are critical components of ESU/DPS spatial structure and diversity. Having all MPGs within an ESU/DPS at low risk provides the greatest probability of persistence for the ESU/DPS. Thus, the ICTRT criterion for a viable ESU/DPS is that all extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS should be at low risk.

The population level assessments provide the basis for evaluation viability at the MPG level and, in turn, for the DPS as a whole. The combined effects of requiring each MPG to sustain a minimum number of viable populations, representation of larger size classes of populations, major life history patterns and the maintenance requirement provide for a network of populations that would sustain the DPS.

Further, the following five criteria should be met for an MPG to be regarded as low risk (viable) (ICTRT 2007b):

1. At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards. This equals to four for this MPG.

2. At least one population should be classified as "Highly Viable."

3. Viable populations within an MPG must include some populations classified (based on historical intrinsic potential) as "Very Large," "Large" or "Intermediate" generally reflecting the proportions historically present within the MPG. In particular, Very and Large populations should be at or above composite historical fraction within the MPG.

4. All major life history strategies (e.g. spring and summer run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.

5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for DPS recovery.

The DPS criterion requiring viable populations in each of the extant MPGs would result in sustainable production across a substantial range of environmental conditions. The presence of viable populations across MPGs would preserve a high level of diversity

within the DPS, thereby promoting long-term evolutionary potential for adaptation to changing conditions. The presence of multiple, relatively nearby, viable and maintained populations acts as protection against long-term impacts of localized catastrophic loss by serving as a source of re-colonization (ICTRT 2007a).

3.2.2 Application of Biological Viability Criteria to Rock Creek Population

Although the risk levels of the populations within the DPS collectively determine MPG viability and, in turn, the likely persistence of the DPS, it may not be necessary for all of the populations to attain the lowest risk level. There may be more than one way for a DPS to meet the viability criteria. The ICTRT called alternative combinations of population risk status that would meet the MPG and DPS-level criteria "recovery scenarios." In a January 8, 2007 technical memorandum (ICTRT 2007a), the ICTRT offered a detailed discussion of possible recovery scenarios for each MPG.

For the Eastern Cascades Slope Tributaries MPG to be viable, four populations representing historical types of diversity in terms of life history, size category, etc., should meet criteria for a low extinction risk, i.e. less than 5 percent risk of extinction (alternatively, more than 95 percent probability of persistence). The Klickitat River, Fifteenmile Creek, and Deschutes West and East populations need to meet low risk criteria because of their life history types and other characteristics. In this recovery scenario, the biological recovery goal for the Rock Creek steelhead population is to contribute to recovery for the Middle Columbia River Steelhead DPS by reaching a "maintained" or moderate risk status (ICTRT 2007a). A maintained or moderate risk is defined as having between 25 and 6 percent risk of extinction within 100 years. To achieve low risk the population would need to meet the 5 percent criterion, and for very low risk, 1 percent. Low and very low risk targets would be consistent with broad-sense goals that have been adopted for populations elsewhere.

The ICTRT classified the Rock Creek steelhead population as a "Basic" sized population, based on historical habitat potential (ICTRT 2007b) and provided viability criteria for a Basic population, as follows (ICTRT 2007b):

Abundance
For a Basic population, viable status, i.e. a 5 percent or less risk of extinction over a 100-year timeframe, would require a mean minimum abundance threshold of 500 naturally produced spawners. Maintained status or moderate (6 to 25 percent) risk would also require a mean minimum abundance of 500 naturally produced spawners because "populations with fewer than 500 individuals are at higher risk for inbreeding depression and a variety of other genetic concerns" (ICTRT 2007b).

Productivity
Productivity rates at relatively low numbers of spawners should, on average, be sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels. For a Basic population at 500 naturally produced spawners to meet the moderate risk criterion, productivity should be at about 1.3 (ICTRT 2007b, Figure 4a). To meet the 5 percent risk criterion (viable status), productivity should be >1.56.

Spatial Structure and Diversity
In general, the ICTRT defined two goals, or biological or ecological objectives, that spatial structure and diversity criteria should achieve (ICTRT 2007b):

- *Maintaining natural rates and levels of spatially mediated processes*. This goal serves to minimize the likelihood that populations will be lost due to local catastrophe, to maintain natural rates of recolonization within the population and between populations, and to maintain other population functions that depend on the spatial arrangement of the population.

- *Maintaining natural patterns of variation*. This goal serves to ensure that populations can withstand environmental variation in the short and long-terms.

Based on historical potential analysis, the ICTRT gave the Rock Creek population a combined integrated spatial structure/diversity rating of Moderate risk. The Rock Creek population has a relatively simple population structure, containing a single major spawning area (MaSA). Although observations indicate that steelhead spawning may occur across much of the historical range, the relatively simple population structure results in a moderate rating for complexity. There have likely been minor reductions in life history diversity and phenotypic variation, but these changes are not severe enough to raise risk levels above low for this parameter.

3.3 Threats Criteria

Listing factors are those features that were evaluated under section 4(a)(1) when the initial determination was made to list the species for protection under the ESA. These may or may not still be limiting recovery when in the future NMFS reevaluates the status of the species to determine whether the protections of the ESA are no longer warranted and the species could be delisted.

At the time of a delisting decision, NMFS will examine whether the section 4(a)(1) listing factors have been addressed. To assist in this examination, NMFS will use the listing factors (or threats) criteria described below in addition to evaluation of biological recovery criteria and other relevant data and policy considerations.

To determine that the affected DPS is recovered to the point that it no longer requires the protections of the ESA, NMFS will review the status of the listing factors according to the specific criteria identified for each of them (see below). The threats need to have been addressed to the point that delisting is not likely to result in their re-emergence. It is possible that current perceived threats will become insignificant in the future due to changes in the natural environment or changes in the way threats affect the entire life-cycle of salmon. Consequently, NMFS expects that the ranking of threats will change over time and that new threats may be identified. During the status reviews, NMFS will evaluate and review the listing factor criteria under conditions at the time.

The specific criteria listed below for each of the relevant listing/delisting factors helps to ensure that underlying causes of decline have been addressed and mitigated before considering a species for delisting. NMFS expects that if the proposed actions described in this plan are implemented, they will make substantial progress toward meeting the following listing factor (threats) criteria.

Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.

To determine that the DPS is recovered, threats to habitat should be addressed to a degree sufficient to support a viable Middle Columbia River steelhead DPS as outlined below:

1. Passage obstructions (e.g., dams and culverts) are removed or modified to improve survival and restore access to historically accessible habitat where necessary to support recovery goals.
2. Flow conditions that support adequate steelhead rearing, spawning, and migration of a viable DPS are achieved where possible through management of mainstem and tributary irrigation and hydropower operations, and through the improvement of other water user efficiencies and conservation, including for municipal supply and other consumptive purposes.
3. Forest management practices that protect watershed and stream functions are implemented on Federal, state, tribal, and private lands.
4. Agricultural practices, including grazing, are implemented to protect and restore riparian areas, floodplains, and stream channels, and to protect water quality from sediment, pesticide, herbicide, and fertilizer.
5. Urban and rural development, including land use conversion from agriculture and forestland to residential uses, avoids impairment of water quality or natural stream conditions.
6. The effects of toxic contaminants on salmonid fitness and survival in the mainstem and tributaries are sufficiently limited so as not to affect recovery.
7. Channel function, including vegetated riparian areas, canopy cover, stream-bank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity is restored to provide adequate rearing and spawning.
8. Floodplain function and the availability of floodplain habitats for salmon are restored to a degree sufficient to support a viable DPS. This restoration should include connectedness between river and floodplain and the restoration of impaired sediment delivery processes.

Factor B: Over-utilization for commercial, recreational, scientific or educational purposes

To determine that the DPS is recovered, any utilization for commercial, recreational, scientific, or educational purposes should be managed as outlined below:

1. Fishery management plans for steelhead are in place that (a) accurately account for total fishery mortality (i.e., both landed catch and non-landed mortalities) and constrain mortality rates to levels that are consistent with achieving population viability (i.e., provide for adequate spawning escapement given their productivity); and (b) are implemented in such a way as to avoid deleterious genetic effects on populations or negatively affect the distribution of populations.

2. Federal, state, and local fishing rules and regulations are effectively enforced.

3. Technical tools accurately assess the effects of the harvest regimes so that harvest objectives are met but not exceeded.

4. Handling of fish is minimized to reduce indirect mortalities associated with education or scientific programs, while recognizing that monitoring, research, and education are key actions for conservation of the species.

5. To the degree necessary to support a viable DPS, routine instream construction and maintenance practices are implemented in a manner to reduce or eliminate mortality of listed species.

Factor C: Disease or predation

To determine that the DPS is recovered, any disease or predation that threatens its continued existence should be addressed as outlined below:

1. Hatchery operations do not subject steelhead populations to deleterious diseases and parasites and do not result in increased predation rates of wild steelhead;

2. Predation by avian predators is managed in a way that promotes recovery of salmon and steelhead populations;

3. The northern pikeminnow and other exotic piscivorous species are managed to reduce predation on steelhead to a degree sufficient to meet recovery goals;

4. Populations of introduced smallmouth bass, walleye, channel catfish and other exotic piscivorous species are managed such that competition or predation does not impede steelhead recovery.

5. Predation of steelhead runs below Bonneville Dam by marine mammals is managed within the framework of applicable statutes and to the degree necessary to protect upstream migration of steelhead.

6. Physiological stress and physical injury that may cause disease or increase susceptibility to pathogens during rearing or migration should be reduced during critical low flow periods (e.g. low water years) or poor passage conditions (e.g. at diversion dams or bypasses).

Factor D: The inadequacy of existing regulatory mechanisms

To determine that the DPS is recovered, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be addressed to the degree necessary to support a viable DPS, as outlined below:

1. Sufficient resources, priorities, regulatory frameworks, and coordination mechanisms are established and/or maintained for effective enforcement of land and water use regulations that protect and restore habitats and for the effective management of fisheries.

2. Habitat conditions and watershed functions are protected through land-use planning that guides human population growth and development.

3. Habitat conditions and watershed function are protected through regulations that govern resource extraction such as timber harvest and gravel mining.

4. Habitat conditions and watershed functions are protected through land protection agreements as appropriate, where existing policy or regulations do not provide adequate protection.

5. Regulatory, control, and education measures to prevent additional exotic plant and animal species invasions are in place.

Factor E: Other natural or manmade factors affecting its continued existence

To determine that the DPS is recovered, other natural and man-made threats to its continued existence should be addressed as outlined below:

1. Hatchery programs are being operated in a manner that is consistent with individual watershed and region-wide recovery approaches; appropriate criteria should be used for the integration of hatchery steelhead populations and extant natural populations inhabiting watersheds where the hatchery fish return.
2. Hatcheries operate using appropriate ecological, genetic, and demographic risk containment measures for (1) hatchery-origin adults returning to natural spawning areas, (2) release of hatchery juveniles, (3) handling of natural-origin adults at hatchery facilities, (4) withdrawal of water for hatchery use, (5) discharge of hatchery effluent, and (6) maintenance of fish health during their propagation in the hatchery.
3. Mechanisms are in place to reduce the incidence of, and impacts from, introduced, invasive, or exotic plant and animal species.

4. Nutrient enrichment programs should be evaluated to determine where additional nutrient inputs can provide significant benefits.

4. Current Status Assessment

This chapter summarizes the ICTRT's viability assessment results for Middle Columbia River steelhead in the Rock Creek watershed. The assessment reflects existing data, previous assessment findings and GIS analysis.

4.1 Abundance and Productivity

At present, no direct estimates of abundance and productivity are available for Rock Creek steelhead. There have been no systematic redd surveys in this population area. The general presence of steelhead has been documented (NPCC 2004). The ICTRT assigned the Rock Creek steelhead population High risk based on the lack of information on current abundance and productivity (ICTRT 2009).

4.2 Spatial Structure and Diversity

The Rock Creek population has a single major spawning area (MaSA) (a system of one or more branches capable of supporting 500 spawners). Steelhead are known to occur in Rock Creek up to a point ¼ mile above the confluence with Quartz Creek (BLM 1985, 1986), and possibly above it. Steelhead have also been located in lower Quartz Creek (BLM 1985, 1986). Steelhead are known to occur in Squaw Creek up to the confluence with Harrison Creek, and have occurred historically as far as the confluence with Spring Creek (C. Dugger, WDFW, pers. comm., 1999). Known utilization includes the lower and middle portions of Rock Creek, lower Quartz Creek and Squaw Creek.

The ICTRT rated the Rock Creek population at Moderate risk for spatial structure/diversity (Table 4-1). Based on the ICTRT historical potential analysis, the Rock Creek population had a relatively simple population structure, containing a single MaSA. Although observations indicate that steelhead spawning may occur across much of the historical range, the relatively simple population structure results in a moderate rating for complexity. There have likely been minor reductions in life history diversity and phenotypic variation, but these changes are not severe enough to raise risk levels above low for the diversity parameter.

Table 4-1 Rock Creek Summer Steelhead Population Spatial Structure and Diversity Risk Rating Summary (ICTRT 2009).

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	H (-1)	H (-1)	(Mean = 0.33) Moderate Risk	Moderate Risk	**Moderate Risk**
A.1.b	L (1)	L (1)			
A.1.c	L (1)	L (1)			
B.1.a	M (0)	M (0)	Moderate Risk (0)	(Mean=0.25) Moderate Risk	
B.1.b	M (0)	M (0)			
B.1.c	M (0)	M (0)			
B.2.a(1)	M (0)	M (0)	Moderate Risk (0)		
B.2.a(2)	L (1)				
B.2.a(3)	L (1)				
B.2.a(4)	VL (2)				
B.3.a	M (0)	M (0)	M (0)		
B.4.a	L (1)	L (1)	L (1)		

4.3 Overall Risk Rating

The Rock Creek steelhead population does not currently meet viability criteria because it is assigned High risk for abundance/productivity (Figure 4-1). The overall spatial structure/diversity rating is Moderate risk. The lack of direct estimates of abundance and productivity for this population was a factor in assigning it High risk.

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1-5%)	**V**	**V**	**V**	**M**
	Moderate (6 – 25%)	**M**	**M**	**M**	**HR**
	High (>25%)	**HR**	**HR**	**HR Rock Creek***	**HR**

Figure 4-1. Integrated Risk Rating for the Rock Creek Steelhead Population (ICTRT 2009). ***Viability Key: HV – Highly Viable; V – Viable; M – Moderate/Maintained; HR – High Risk; * = Candidate for Maintained; Shaded cells – does not meet viability criteria (darkest cells are at greatest risk).***

5. Limiting Factors and Threats

The reasons for a species' decline are generally described in terms of limiting factors and threats. Analysis of limiting factors and threats across the entire species' life cycle forms the basis for designing recovery strategies and actions. NMFS defines limiting factors as the biological and physical conditions limiting DPS and population status (e.g. elevated water temperature), and defines threats as those human activities or naturally induced actions that cause the limiting factors (e.g. removal of riparian vegetation for agricultural or residential purposes, which causes loss of shade and, consequently, elevated water temperature).

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are typically legitimate human activities that may at times have unintended negative consequences on fish populations—and that can also be managed in a manner that minimizes or eliminates the negative impacts.

For steelhead and other salmonids, survival to reproduce depends on a complex, interacting system of environmental conditions, with different conditions needed for each life stage. Optimal water temperature, for example, varies (within limits) for adult migration vs. egg incubation or juvenile rearing. In addition, the particular factors limiting production may vary across different sections of the tributary drainage used by a particular population. Data on a full range of potential limiting factors is rarely available at the reach level.

The list of potential limiting factors for the Rock Creek steelhead population, as for the other populations that make up the Middle Columbia steelhead DPS, is based on a substantial body of research on salmonids, local field data and field observations, and the considered opinions of regional experts. These are implicitly hypothetical statements to be tested, made with the expectation that by taking action in the face of some degree of scientific uncertainty, monitoring the results, continuing to conduct research to further characterize the factors limiting the population, and adapting our management actions in response, the state of our knowledge will improve and so will the survival of these fish, although not necessarily in a directly parallel process. This chapter describes factors that may be limiting Middle Columbia River steelhead production in the Rock Creek subbasin.

5.1 Freshwater Habitat

Low summer flows and high summer water temperatures occur naturally in some parts of the Rock Creek watershed because of bedrock terrain and steep slopes. The intensity of some of these factors may have increased because of anthropogenic changes in the subbasin. For example, historical forest practices, including logging and road construction, adversely impacted functional quality of riparian areas in some portions of the headwaters and canyon reaches (e.g., upper Rock Creek, Box Canyon and Quartz

Creek) (NPCC 2004). In addition, channel widening and incision, such as along lower Rock Creek, could cause a reduction or loss of summer base flows.

While the Rock Creek watershed is sparsely populated, anthropogenic influences occur throughout the subbasin. Much of the watershed has been grazed or logged, and primitive roads extend from near the Columbia River to the headwaters of most streams in the subbasin. Beaver were once likely abundant and are now less common. Still, while grazing, roads, and other uses may contribute to habitat problems in some parts of the watershed, considerable forest canopy remains and most stream reaches support at least shrub-dominated riparian areas.

The major factors and associated threats that potentially limit abundance, productivity, spatial structure and diversity of Middle Columbia River steelhead in the Rock Creek watershed are discussed briefly below. The factors were identified based on information in the Northwest Power and Conservation Council's subbasin plan for the Lower Mid-Columbia Mainstem, including Rock Creek (NPCC 2004) and the Watershed Assessment for Rock Creek, part of WRIA 31 (Aspect Consulting and WPN 2004). They also reflect the input data for an Ecosystem Diagnosis and Treatment (EDT) model for Rock Creek (available at: http://edt.jonesandstokes.com/).

The stakeholders in the Rock Creek–Glade Creek watershed completed and approved in April 2009 the WRIA 31 Watershed Management Plan (WRIA 31 Planning Unit et al. 2008), with the help of the State of Washington under the Watershed Management Act pursuant to chapter 90.82 Revised Code of Washington. The watershed plan includes identification of prioritized fish habitat issues and actions in the Rock Creek–Glade Creek watershed. In the fall of 2008 through spring of 2009, a quantitative instream habitat assessment and fish survey was conducted on non-Tribal lands in the Rock Creek watershed (Glass 2009). Fish habitat was assessed with a stratified random sample design incorporating the entire area indicated as potentially containing steelhead (Figure 2-7 of this document). The total stream length assessed was 11,700 meters, or 14.5 percent of a study area (Glass 2009). Potential limiting factors and threats identified in Glass 2009 and WRIA 31 Planning Unit et al. 2008 are incorporated in this summary.

- ***Hydrograph.*** Seasonally low to non-existent stream flows might be a primary factor limiting steelhead production in the Rock Creek watershed. Low to intermittent and/or subterranean flows in all streams during late summer, fall and early winter can limit juvenile mobility and cause mortality due to stranding. The historical information, coupled with documented intermittent conditions (USGS 1989; Ecology's gaging station, https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=31B070), which occur under minimal human water use (Aspect Consulting and WPN 2004), suggest that the streamflow in Rock Creek is naturally intermittent rather than a condition created by human development (Aspect Consulting and WPN 2004). However, the loss of riparian vegetation, instream habitat complexity and diversity, and floodplain connectivity in some reaches because of grazing, roads, and/or other land uses can increase the intensity of flows in some parts of the drainage. In the

Rock Creek subbasin, roads are at low density (Coe 2004, Harr et al. 1975, Aspect Consulting and WPN 2004). The amount of vegetation in the valley bottom has been increasing since 1938, presumably due to fire suppression (Aspect 2005). Most of the land in the basin is lightly grazed. Low summer stream flows occur in the lower part of the subbasin ─ lower Rock Creek mainstem, lower Squaw Creek, and lower Luna Gulch ─ but also occur in some headwater and canyon reaches (NPCC 2004, Ecology's stream gage https://fortress.wa.gov/ecy/wrx/wrx/flows/station.asp?sta=31B070). None of the stream length of the Rock Creek mainstem above the Bickleton Bridge to the upper extent of steelhead distribution (Figure 2-7) was dry in mid-October/early November 2008, although measured flow in the lower mainstem was zero (Glass 2009). Flow in some of lower Rock Creek is below the surface because of the high proportion of alluvial material in the substrate. Approximately 14 percent of the stream length was dry in the reaches of the Rock Creek subbasin surveyed in mid-October/early November 2008 when measured flow in the lower mainstem was zero. Spring outflows feed some reaches and pools, and may provide important refugia during periods of low flow.

- ***Water quality, high stream temperatures.*** Seasonally high water temperature is potentially a primary factor limiting steelhead production in the Rock Creek watershed (Glass 2009). As noted in Chapter 2, the range of temperatures steelhead can tolerate varies with life stage and other characteristics. Temperatures above 13.3ºC (56ºF) can result in egg mortality (McEwan and Jackson 1996), and sufficient oxygen may not be available above 21.1ºC (70ºF) (ibid.). Steelhead are considered to do best at a range of 12.8-15.6ºC (55.0-60.1ºF) (Rich 1987). Temperatures above 22ºC (72ºF) are highly stressful for steelhead. The Washington State water quality criteria for aquatic life list 63.5º F as the maximum for salmonid spawning, rearing, and migration; temperatures above 63.5º F can be lethal to developing fish embryos (WAC 173-201A-200).

  Summer water temperatures in the lower Rock Creek subbasin frequently rise above 63.5°F (Aspect 2005). With respect to steelhead incubation, some lower reaches of Rock Creek and Squaw Creek start exceeding 63.5°F in mid- to late-May and in some reaches rise above 73.4°F (23.9°C) (Aspect Consulting 2005), a level considered potentially lethal for salmon and steelhead (Glass 2009). One reach of Rock Creek is listed twice on the Washington State Department of Ecology's 2008 water quality assessment (known as the 303(d) list) as being impaired for water temperature (Category 5), and requiring a TMDL (http://apps.ecy.wa.gov/wats08/ViewListing.aspx?LISTING_ID=7967). Loss of habitat quantity and diversity, channel degradation due to flooding and other factors, low summer flows, and loss of riparian vegetation can contribute to this potential limiting factor. High stream temperatures during summer and early fall, especially in the lower watershed, limit juvenile mobility and may result in stranding or mortality because of thermal stress (NPCC 2004). Potential anthropogenic effects on stream temperature have not been quantitatively evaluated; however, the evidence suggests that high water temperatures in Rock

Creek are a natural condition (Ehinger 1996, Aspect Consulting and WPN 2004, Aspect Consulting 2005). The amount of vegetation in the valley bottom has been increasing steadily since 1938, presumably due to fire suppression (Aspect Consulting 2005). Fine sediment levels in the basin tend to be low (Glass 2009), which suggests that filling of pools or widening of the stream, which would contribute to warm temperature, is unlikely.

- ***Riparian function and condition.*** While the stream system's rocky substrate and steep topography naturally inhibit riparian forest stand development along many reaches, riparian function and condition have been affected by major flood events, grazing, historical timber practices, road construction, and other land uses. Since 2006, commercial forestry in the Rock Creek watershed is managed under a NMFS-approved Habitat Conservation Plan (HCP): the Forest Practices HCP, or FPHCP, which applies to private commercial timberlands regulated by State Forest Practice Rules. Tribal harvest is managed under the Yakama Nation Forest Management Plan. Glass (2009) concluded that the magnitude of the anthropogenic effects is likely minor, because roads are sparse, largely located upslope of streams, and likely input little sediment (Aspect Consulting and WPN 2004); harvest in riparian areas is highly regulated; and there is little development in the basin (Klickitat County Assessor's Office http://www.klickitatcounty.org/Road/ContentROne.asp?fContentIdSelected=455695186&fCategoryIdSelected=-342308583&fX=X). Grazing affects portions of the Rock Creek watershed; its impacts can be directly observed in the lower mainstem. A 1995 stream habitat evaluation along Rock Creek showed that six of ten sites examined during the evaluation had riparian vegetative cover more than 10 percent below the target for eastern Washington Class A streams (Aspect Consulting and WPN 2004; Ehinger 1996).

- ***Channel structure and complexity.*** Degraded channel structure and complexity in the subbasin may reduce key habitat quantity and habitat diversity for steelhead. Key habitat quantity refers to the amount of key habitat, such as riffles, that is present in the stream for each life stage. If key habitat is limited, fewer steelhead can be supported by the stream. Habitat diversity refers to the extent of habitat complexity, such as large wood, boulders, undercut banks and pools, and the processes that form pools and cover within a stream reach. Greater complexity increases survival and provides better habitat. Large wood in the stream plays a major role. Instream wood in the basin is low relative to streams of the Cascade Mountains (Glass 2009); however, riparian density has been increasing for at least 70 years (Aspect Consulting and WPN 2004), and increases in recruitment of instream wood are expected as the riparian stands mature.

  Glass 2009 estimated the area of spawning habitat in the Rock Creek subbasin at 59,506 square meters and the volume of pools at low flow at 4,229 cubic meters (Glass 2009). Findings from a reconnaissance survey of portions of Rock Creek indicate that the creek's general channel characteristics may be similar to those noted in an 1860s survey (e.g., broad rocky reaches), with the exception that the

lowermost reach may be wider today than historically (Aspect and WPN 2004). Over the years, however, key habitat quantity and habitat diversity have declined in some reaches due to disturbance of channel and riparian habitats from grazing, historical timber harvest, road construction, other anthropogenic changes and from major flood events. These factors could potentially have contributed cumulatively to changes in the hydrograph, altering available perennial wet habitat as well as decreasing riparian quality and function and instream habitat and function. In addition, key habitat quantity and habitat diversity have been lost in the one-mile reach above Rock Creek's mouth as a result of inundation by Lake Umatilla behind John Day Dam on the Columbia River.

- ***Floodplain function and channel migration processes.*** The stream channel in lower Rock Creek is highly dynamic and moves across the valley bottom with regularity, likely switching channels during flood flows. One of the more dynamic sections of the stream channel is upstream of the Old Highway 8 Bridge, where the channel changed courses many times over the period of photo record, and has distinctly different courses in 1938, 1969, 1996, and 2002 (Aspect Consulting 2005). Bridges for the Bickleton Highway and Old Highway 8 have locally increased hydro confinement, constricting flow and channel migration processes. The Bickleton Bridge is scheduled for replacement with a longer spanned bridge. A series of dikes also exists in a middle mainstem Rock Creek reach that limit the stream's ability to meander. Extensive grazing, historically and currently, could potentially diminish riparian health and affect channel plain form in some reaches of the lower watershed, decreasing channel stability. However, most of the basin is lightly grazed, and grazing effects tend to be localized (Glass 2009). Although beavers have been observed near Luna Gulch (Glass 2009) and likely are present elsewhere in the basin, their abundance is likely lower than the historical population level.

- ***Sediment routing.*** Sediment loads (the percentage of fines in spawning gravel, embeddedness and turbidity) in the Rock Creek subbasin may have increased over historical conditions. Actions potentially contributing to increased sediment delivery include historical forest practices (skidding and road building, clearing of upland forests and stream banks), agricultural and grazing practices (rill irrigation, streamside grazing), and road building and maintenance activities.

  However, there is no commercial irrigation in Rock Creek, most of the basin lands are lightly grazed, and roads are sparse and largely located upslope from streams (Aspect Consulting and WPN 2004). These would tend to minimize the anthropogenic effects on sediment routing. A recent study that evaluated sediment loads in 278 riffles located throughout the basin found that only two of the riffles, both located in backwater areas, had fine sediment levels that exceeded 20 percent fines (Glass 2009). All other riffles had less than 20 percent fines and the majority of the riffles had less than 15 percent fines (Glass 2009). Previous studies have found these levels to have little effect on survival of eggs and alevins (Tappel and Bjornn, 1983, Chapman 1988).

- ***Competition for food sources.*** Changes in the hydrological regime and riparian conditions affect the food web and thus increase competition among species. Macroinvertebrates can be produced in reduced quantities where there are poorly functioning hyporheic zones, diminished pool and riparian presence, and a lack of stream structure. To date, there has been no assessment of food production or competition for food in the basin.

- ***Predation and competition.*** Inundation of the lower one mile of Rock Creek by the waters of Lake Umatilla behind John Day Dam may have increased access of piscivorous fish such as smallmouth bass, channel catfish, and northern pikeminnow to the lower mile of Rock Creek and the reservoir through which the steelhead must travel. However, no exotic piscivorous species were observed above the inundated area during snorkel surveys conducted in Rock Creek, Luna Gulch, and Squaw Creek during October and November of 2008 (Glass 2009). No evaluation has been done on the effects of predation and competition on the Rock Creek steelhead population.

  The ISAB (2007 and 2008) concluded that the Columbia River impoundments have created sloughs and backwater habitats where water exchange is very low and summer water temperatures are often several degrees warmer than the nearby main-channel habitats. As a consequence, introduced resident fish such as smallmouth bass and channel catfish are expanding into these habitats. The ISAB 2007 also commented that increases in water temperature would favor further expansion of warm-water piscivores. Hence, the potential for predation could increase over time.

5.2 Hatchery Effects

Anadromous fish production within the subbasin is almost exclusively natural. Steelhead are not stocked in Rock Creek, and very few fin-clipped steelhead have been observed in the subbasin. Hatchery strays of upriver origin may enter and spawn in Rock Creek, but the effects of out-of-subbasin hatchery programs on the Rock Creek steelhead population are unknown.

5.3 Tributary Harvest

Rock Creek and its tributaries are open to steelhead and trout fishing from June 1 to October 31 annually (trout over 20 inches are considered steelhead), and the area inundated by the John Day Pool (up to the Army Corps of Engineers Park at river mile 1) is open year around to allow for warm water fisheries and for trout over 12 inches (trout over 20 inches are considered steelhead) from June 16 to March 31. Only adipose fin-clipped steelhead may be retained (WDFW 2008a). Adult steelhead are not present in Rock Creek during the summer because of low or non-existent flows. They enter the creek after flows resume and temperatures drop, generally after the season is closed. Some minor tribal catches for ceremonial purposes are reported, but they are currently considered insignificant (Bill Sharp, Pers. comm. 2008). Poaching has been observed in

the subbasin, however, and is considered a problem. While increased patrols are desired, funding levels are mostly inadequate to provide for such services.

The fishery targeting other species at the mouth of Rock Creek is quite active at times and it is expected that some steelhead are unintentionally caught by recreational anglers, of which only marked hatchery fish are permitted to be retained. Better educational opportunities at the Army Corps of Engineers Park may assist in preventing accidental catch and retention of wild steelhead.

The overall mortality rate for catch-and-release adult steelhead fisheries depends on the encounter rate of naturally produced fish (percentage of run actually caught and released) in the fisheries, and the mortality rate associated with being caught and released (hook-and-release mortality). In winter steelhead fisheries, WDFW (2008b) estimates that catch-and-release mortality is less than 5 percent, while mortality in summer steelhead fisheries is estimated to be higher, less than 10 percent of the wild fish handled, reflecting high temperatures. The catch and release mortality only affects that proportion of the wild run encountered in the fishery. WDFW (2008b) estimates that in the Rock Creek tributary fisheries less than 5 percent of the steelhead are handled, due to the closure of Rock Creek during the period adult steelhead would be present, and the limited effort during the time that steelhead may be present below the Army Corps of Engineers Park. Multiplying the catch and release mortality rate by the encounter rate provides the estimate of tributary fisheries impacts of less than one percent wild steelhead (WDFW 2008b). For further evaluation of the harvest rate, please see the Middle Columbia River Steelhead DPS Recovery Plan.

Steelhead occupy many waters that are also occupied by resident trout species. It is not possible to visually separate juvenile steelhead from similarly sized stream-resident rainbow trout. Because juvenile steelhead and resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout also apply to juvenile steelhead. WDFW has implemented a number of regulation changes to limit impacts on juvenile steelhead in Rock Creek. These include increasing the minimum size limit for rainbow trout fisheries from 6 inches to the current size limit of 8 inches in the tributary and 12 inches below the Army Corps of Engineers Park. The daily bag limit was also reduced from 6 fish to 2 fish. Trout angling is only open from June 1 to October 31 in the tributary, and June 16 to March 31 in the area below the Army Corps of Engineers Park. These changes have reduced impacts on naturally produced juvenile steelhead/trout to less than 1 percent of the population, a substantial reduction from historical impacts of tributary fisheries that were estimated to be over 50 percent in some Middle Columbia River steelhead basins (WDFW 2008b). Rainbow trout are not released into Rock Creek, and this also reduces harvest impacts. Fisheries that target non-resident warm water species can affect juvenile steelhead, but these fisheries are limited to the area below the Army Corps of Engineers Park (WDFW 2008a). WDFW has submitted to NMFS a Fisheries Management and Evaluation Plan (FMEP) for tributary fisheries in the Middle Columbia steelhead DPS to cover impacts from these fisheries under the 4(d) rule limit 4 of the ESA (WDFW 2008b). This FMEP,

when finalized, will have all the site-specific actions for the tributary fisheries. NMFS expects the FMEP to be completed in 2010.

5.4 Out-of-Subbasin Limiting Factors and Threats

The Middle Columbia River Steelhead DPS Recovery Plan uses information from two "modules" developed by NMFS to address conditions in the Columbia River mainstem and estuary that affect all Middle Columbia steelhead: the Hydro Module, based on the NMFS 2008 Biological Opinion on the Federal Columbia River Power System (NMFS 2008b), and the Estuary Module (NMFS 2007b). In addition to proposed actions in the management unit plans, the DPS Plan relies upon Hatchery and Genetic Management Plans and Artificial Production for Pacific Salmon (Appendix C of the Supplemental Comprehensive Analysis, NMFS 2008 Biological Opinion) to address hatchery effects. For harvest effects, the Plan refers to fishery management planning through the 2008 U.S. v. Oregon agreement for mainstem fisheries, and Fisheries Management Evaluation Plans for tributary fisheries. The reader is referred to the DPS plan for this information. The following is a summary of the information most relevant to the Rock Creek plan.

5.4.1 Harvest

Without more data on Rock Creek steelhead abundance, and without targeted tagging of Rock Creek fish, the percentage of Rock Creek steelhead that are harvested in the Columbia River cannot be specifically calculated. However, it may be inferred that Rock Creek steelhead are subject to the same relatively low overall harvest rate estimated for other Middle Columbia steelhead. Washington Department of Fish and Wildlife (2008) estimates that in 2002, tributary fisheries in the Rock Creek area affected about 1 percent of the adult steelhead and less than 1 percent of the juvenile steelhead. Mainstem non-treaty commercial and recreational fisheries have an estimated impact of 1.6 percent of the A-run Middle Columbia steelhead (NMFS 2008a), and mainstem treaty fisheries have an estimate 6.64 percent impact (NMFS 2008a) for an overall estimated harvest impact of less than 10.24 percent.

The various fisheries that may harvest Rock Creek steelhead as they migrate through the Columbia River and Pacific Ocean are the following.

Ocean Fisheries

Since steelhead are rarely caught in ocean fisheries, these fisheries are not considered a significant source of mortality to Middle Columbia River steelhead (NMFS 2000). Ocean fishing mortality on Middle Columbia River steelhead is assumed to be zero.

Columbia River Mainstem Non-Tribal Fisheries

There has been no direct freshwater non-tribal harvest on wild steelhead from the Mid-Columbia DPS since 1992, when the last wild fish catch-and-release regulations on these populations became effective. Therefore, all current non-tribal harvest impacts on Mid-Columbia DPS steelhead are due to incidental bycatch in commercial or recreational fisheries that target hatchery steelhead or other species, and monitoring these impacts is complex. Released fish experience a mortality rate, possibly delayed and difficult to

measure, that is highly variable and depends on what gear is used, how the fish is caught by the gear, how the fish are handled during capture and release, and environmental conditions. Release mortality is estimated to be very low (below 1 percent of encounters), with an unknown range of error. Recreational fisheries are monitored by creel surveys (fisheries technicians interview anglers about their catch, gear, and wild steelhead releases); the total recreational impact on winter and summer steelhead as they move through the mainstem to the tributaries is estimated to be less than 2.5 percent (Carmichael 2009).

There are three stocks of summer steelhead used for management of treaty and non-treaty mainstem fisheries, including the lower Columbia River Skamania stock, upriver A-run stock, and upriver B-run stock. All MCR steelhead populations are designated A-run, except the two winter-run populations. In NMFS' Biological Opinion for the 2008-2017 *U.S. v. Oregon* Fisheries Agreement (NMFS 2008a), the wild MCR steelhead DPS in the non-treaty winter, spring, and summer mainstem fisheries are subject to a 2 percent harvest rate limit. Non-treaty fall fisheries are also limited to a 2 percent harvest rate limit for A-run summer steelhead. The total annual harvest rate limit for A-run steelhead in non-treaty fisheries is 4 percent and 2 percent for the summer-run and winter-run of the MCR steelhead DPS, respectively. The expected harvest impacts from non-treaty fisheries are less than the limits proposed in the *U.S. v. Oregon* fisheries Agreement. The yearly incidental catch of A-run steelhead in non-treaty fisheries has averaged 1.6 percent since 1999, and are not expected to change over the course of the Agreement (NMFS 2008a).

Treaty Native American Fisheries

Tribal fishers in Zone 6 of the Columbia mainstem (between Bonneville Dam and McNary Dam) continue to retain wild steelhead for commercial sale or for personal use. Impacts on MCR steelhead from treaty-Native American fall fisheries that affect summer-run steelhead populations including Rock Creek are limited by harvest rate limits for B-run steelhead and Upper Columbia River bright fall Chinook (NMFS 2008a). The harvest rate on MCR summer-run steelhead in spring, summer, and fall Zone 6 treaty-Native American fisheries combined averaged 11.7 percent since 1985 and 6.64 percent since 1998 (NMFS 2008b, Table 8.8.5.5-1). The impacts resulting from the treaty-Native American fisheries are expected to be similar to the 1998-2006 average of 6.64 percent. The harvest rate is less for populations that pass fewer dams in Zone 6 and are therefore subject to fewer non-Native American and treaty-Native American fisheries.

5.4.2 Columbia River Hydropower Operations

Hydrosystem construction and operation (flow regulation) in the Columbia River Basin has been a major cause of changes to the Columbia River and estuary from historical conditions. The effects of Columbia River hydro operations on salmonids are reviewed briefly here and described in detail in two NMFS documents: the 2008 FCRPS Biological Opinion (NMFS 2008b) and the Hydro Module (NMFS 2008c).

Within the Rock Creek subbasin, steelhead and salmon were directly affected by the creation of the John Day Dam on the mainstem Columbia River, which effectively inundated the lowest reach of Rock Creek, reducing riparian habitat and increasing predation by native and non-native fish in the lower river. A lack of historical data inhibits quantitative evaluation of the impacts of John Day pool inundation on native fish, plant, and wildlife species.

In the mainstem Columbia River, changes in river flow, circulation, water quality, contaminants, channel alterations, and predation have negative impacts on adult and juvenile fish. Hydro operations have changed flow conditions in the Columbia River and through the estuary. Before the development of the hydrosystem, Columbia River flows were characterized by high spring-runoff from snowmelt and regular winter and spring floods. Dam construction and operation have altered Columbia River flow patterns substantially throughout its basin. Historical flow records at The Dalles and Bonneville Dam demonstrate that annual peak flows have been reduced by about 50 percent, as water is stored for power generation and irrigation, and winter flows have increased approximately 30 percent.

The Columbia River Estuary Module http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery -Plans/upload/Estuary-Module.pdf, provides more information on factors that limit viability of Rock Creek steelhead in the Columbia River estuary.

5.4.3 Ocean Conditions

The effects of ocean conditions on abundance of Pacific salmon and steelhead vary among species and populations within species. Migration patterns in the ocean may differ dramatically and expose different stocks to different conditions in different parts of the ocean. Some species have broad, offshore migration patterns that may extend as far as the Gulf of Alaska (steelhead, chum, some Chinook). Others have migration patterns along the Washington, British Columbia, Oregon and California coasts (Chinook, coho, cutthroat). Thus, ocean conditions do not have coincident effects on survival across species or populations.

Ocean survival of steelhead has been dramatically affected by widespread changes in ocean conditions. Cooper and Johnson (1992) showed that variation in steelhead run sizes and smolt-to-adult survival was highly correlated between runs up and down the West Coast. Smolt-to-adult survival rates generally varied 10-fold between good and bad years. Ocean survival rates for three West Coast steelhead populations where good annual index data were available showed high variability and a generally declining trend since the late 1970s.

5.4.4 Climate Change

Climate change represents a potentially significant threat to recovery of Rock Creek steelhead, as well as Mid-Columbia steelhead DPS. The Independent Scientific Advisory Board (ISAB) for the Northwest Power and Conservation Council, Columbia River Basin Indian Tribes, and NMFS reviewed the potential effects of climate change on salmonids

in the Columbia River basin (ISAB 2007). The ISAB report shows that changes in climate may adversely affect steelhead in freshwater habitats across the DPS by exacerbating existing problems with water quantity (lower summer streamflows) and water quality (higher summer water temperatures). Consistently identified types of impacts on snow pack, stream flow, and water quality in the Columbia Basin are the following (ISAB 2007):

- Warmer temperatures will result in more precipitation falling as rain rather than snow.
- Snow pack will diminish, and the timing of stream flow will be altered.
- Peak river flows will likely increase.
- Water temperatures will continue to rise.

These changes may affect steelhead more than other salmonids because of their long rearing period in freshwater and sensitivity to water temperature.

Changing conditions could also affect salmonid health and survival in the ocean through a variety of mechanisms, including increased ocean temperatures, increased stratification of some waters, changes in the upwelling season, shifts in the distribution of salmonids, long term variability in winds and ocean temperatures, increased acidity, and increased atmospheric and oceanic variability. (NMFS 2007b, 2008a; ISAB 2007)

All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat can be expected to cause a reduction in the number of naturally produced adult steelhead returning to these populations across the DPS. This possibility further reinforces the importance of achieving survival improvements throughout the entire steelhead life cycle. Recent research also indicates that neighboring populations with differences in habitat may show different responses to climate changes (Crozier and Zabel 2006; Crozier et al. 2008). This research reinforces the importance of maintaining habitat diversity.

5.4.5 Other Large-Scale Threats

- Projected continued population growth will increase pressures for conversion of forestry and agricultural land uses to residential uses, with potential impacts on habitat and water conditions.
- Increase in exotic invasive species that potentially compete with native flora and fauna, and provide food and/or cover to species that potentially compete with, prey on or carry diseases which could affect native species.
- New disease and/or pathogen introductions (e.g. from marine aquaculture operations on steelhead ocean migration routes, illegal stocking of out-of-subbasin species).
- Natural catastrophic events (e.g. earthquake, volcanic eruption and related effects).

6. Recovery Strategy and Actions

The preceding chapters summarize recovery goals, biological criteria and threats criteria, current status assessment, and the limiting factors and threats identified for the Rock Creek steelhead population. How will we reach recovery? In this chapter, a recovery strategy is described to address the significant data gaps and uncertainties regarding the status of the Rock Creek steelhead population and to address the potential limiting factors based on the existing, best available science. In addition, Appendix II details the many efforts already underway to improve and protect watershed conditions in the Rock Creek subbasin—efforts that will benefit salmonids as well as other wildlife and human communities.

Lack of information about the Rock Creek steelhead population is a major problem for recovery planning for the Middle Columbia River steelhead DPS. Using the ICTRT criteria for DPS viability, this population needs to achieve "maintained" or moderate risk status for the DPS to be considered viable. The Rock Creek population's high risk rating was assigned primarily on the basis of uncertainty and lack of information on current abundance and productivity. Thus, research and monitoring to resolve the uncertainties and address data gaps is a top priority. Although some published and unpublished data are available, some disagreement also exists among regional experts concerning limiting factors and threats for the Rock Creek steelhead population. Further research will help to resolve these disagreements.

NMFS believes existing information and analyses are adequate to suggest a recovery trajectory and a scale of effort that can reasonably be expected to achieve the goal. A collaboratively designed implementation program that includes a research, monitoring, and evaluation (RM&E) plan to support adaptive management will allow managers the flexibility to continue or change course in response to new information.

The overall aim of the recovery strategy is to gather needed data on the Rock Creek steelhead population and the watershed, while also addressing the potential limiting factors in a manner that is most likely to contribute to improved viability. The strategies and actions were defined through review and analysis of currently available information. They are consistent with actions identified in the Lower Mid-Columbia Mainstem Subbasin (including Rock Creek) Management Plan (NPCC 2004), and address risks identified in the ICTRT's viability assessment for the population.

6.1 Strategies and Actions

The Plan proposes a number of strategies and actions to address data gaps and potentially limiting factors, assess anthropogenic effects, and implement actions to rebuild the Rock Creek steelhead population to the desired level of viability.

6.1.1 Gather Information on VSP Parameters

Information on population abundance, productivity, spatial structure, and diversity is needed to set priorities and determine the actions that will make the greatest contribution to steelhead recovery. Needed actions include initiating systematic surveys to calculate

abundance and productivity, completing a gap analysis, characterizing spatial distribution and genetic variation, and evaluating hatchery contribution to naturally spawning steelhead in the Rock Creek subbasin.

6.1.2 Protect and Conserve Existing Good Quality Habitat

Protecting existing good quality habitat is a high priority. Many objectives are likely to be met through habitat protection and the associated natural recovery of upland and riparian areas. Protection and maintenance includes compliance with existing rules and regulations, such as the State Forest Practices Act, the State Shorelines Act, and other State, County, and local regulations designed to protect aquatic habitat. Protection may also incorporate a wide range of voluntary actions such as fencing riparian areas, participation in the various agricultural land reserve programs, and voluntarily implementing programs that help to avoid impacts to aquatic resources. Land acquisitions, easements, cooperative agreements, and protective land designations can also be used to facilitate high quality habitat protection.

6.1.3 Restore and Enhance Habitat and Gather Information

Restoration and enhancement of habitat conditions for salmon and steelhead populations should improve population production. The value of these actions to the viability of the population will depend on whether or not they address the factors currently limiting the population or threats associated with factors that are now, or are trending toward, becoming limiting, e.g. climate change. The success of these strategies is further enhanced when actions build from existing restoration efforts and incorporate a range of project types.

- Conduct research to further evaluate factors and threats limiting habitat diversity in the Rock Creek watershed.

- Improve instream flow during critical periods. The seasonally low to intermittent stream flow in the area of steelhead distribution upstream of the Columbia River backwater is a likely limiting factor on abundance, productivity, spatial structure, and diversity. Low flow can result in stranding and mortality to eggs or juvenile steelhead. Further study is required to determine causes of low flow, whether anthropogenic or natural, and options to enhance stream flow.

- Improve water quality, reduce summer high temperatures. Water temperature is directly related to riparian vegetative cover and other watershed characteristics such as channel complexity, floodplain function, and upland processes. Hence, many types of habitat actions are likely to function together to improve water quality, particularly water temperature. The more directly related actions to improve water quality include the following:
    - Restore riparian vegetative cover with appropriate native vegetation to increase shading.
    - Develop sediment control basins.
    - Manage livestock grazing in the riparian areas.

  - Increase deep pool habitat.

- Improve/restore riparian function and condition. Actions to address this potential limiting factor include the following:
  - Restore riparian vegetative cover with appropriate native vegetation.
  - Manage livestock grazing in riparian areas.
  - Eradicate invasive plant species from riparian areas.
  - Relocate beaver to suitable areas.

- Increase key habitat by improving or restoring channel structure and complexity. Key habitat, as described in Chapter 5, refers to characteristics such as riffles, pools, suitably aerated gravel, etc. that are essential to each steelhead life stage. The following actions would increase key habitat:
    - Introduce large woody debris (LWD) and other structures in stream as appropriate.
    - Improve riparian vegetation to provide future source of LWD.
    - Stabilize and protect stream banks.
    - Fertilize streams with fish carcasses.

- Improve and/or restore floodplain function and channel migration processes. Reconnecting floodplain habitats and side channels would provide additional sheltered rearing areas. Increasing LWD and other actions such as relocating floodplain infrastructure where feasible, implementing road management BMPs or decommissioning roads as appropriate, could restore floodplain function, moderate the "flashiness" of the stream, and moderate peak flows.

- Improve or restore optimal sediment processes. Watershed processes of runoff and sediment production can be improved through restoring native upland plant communities, implementing appropriate upland management practices, managing off-road vehicle usage to reduce erosion and fine sediment, and managing roads to reduce fine sediment inputs to the stream.

- Conduct research to determine status of food web and presence or absence of competition from other species for food resources.

- Conduct research to determine presence and extent of predation on steelhead by non-native species such as piscivorous fish.

6.1.4 Review and Reduce Effects of Harvest

As described in Chapter 5, only adipose fin-clipped steelhead are allowed to be retained in sport or recreational fisheries in Rock Creek and throughout the Columbia River, but wild steelhead may be accidentally caught and/or retained. Poaching is also considered a problem. Actions to address harvest effects include better review of current practices, enforcement of regulations, and considering whether any modifications are needed. Outreach and education to reduce retention or handling mortality is also recommended.

6.1.5 Research Effects of Hatchery Fish (If Any)

As described in Chapter 5, hatchery strays of upriver origin may enter and spawn in Rock Creek, but no data are available on this issue. Monitoring for hatchery fish should be included in the RM & E program to be developed collaboratively after this plan is adopted.

6.1.6 Address Out-of-subbasin Limiting Factors

Out-of-subbasin limiting factors for Rock Creek steelhead may include hydroelectric operations, harvest, interactions with hatchery fish, predation, food, disease, competition, and ocean conditions. Actions to address these factors for all Middle Columbia steelhead are presented in the Columbia River Estuary Module (NMFS 2007b) and the 2008 FCRPS Biological Opinion (NMFS 2008b), summarized in the Hydro Module (NMFS 2008c).

6.2 Summary of Recovery Strategy

Table 6-1 summarizes the recovery strategy designed to improve the viability of Rock Creek steelhead. The table links strategies and actions to the factors and threats potentially limiting steelhead viability in the subbasin, and the viability parameters and life stages that would be most affected. Priority locations are provided for some strategies, with stream reaches or areas where actions should be applied first to gain the greatest benefit.

Table 6-1. Recovery Strategy and Actions for the Rock Creek Population of Middle Columbia Steelhead.

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
Gather information on population size and productivity	• Gather information to calculate abundance and productivity estimates	Entire Watershed	Addresses a primary risk factor	N/A	N/A	abundance and productivity	N/A
Gather information on population spatial structure and diversity	• Conduct surveys to determine steelhead distribution. • Identify major life history strategies • Conduct studies to address genetic variation in the population • Assess the contribution of hatchery-origin steelhead to the natural spawning population	Entire Watershed	Addresses a primary risk factor	N/A	N/A	spatial structure and diversity	N/A
Gather information to further evaluate habitat limiting factors and threats in the basin	• Conduct surveys to evaluate factors affecting habitat quantity. • Conduct surveys to evaluate factors affecting habitat quality. • Conduct surveys to evaluate factors affecting habitat function.	Entire Watershed	Addresses a primary risk factor	N/A	All life stages	All VSP parameters	N/A
Protect and conserve natural ecological processes that support steelhead viability throughout the life cycle	• Apply BMPs to livestock grazing practices • Apply BMPs to road system management • Apply BMPs to agricultural practices to control erosion and runoff • Manage stream corridor through conservation easements and/or land acquisition from willing sellers • Adopt and manage cooperative agreements	Throughout watershed	Key habitat quality and diversity, sediment inputs, water quality, stream flow	Road and grazing management activities	All life stages	abundance, productivity, spatial structure and diversity	Immediate for sediment, other parameters 5-15 years

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
Improve instream flow during critical periods	• Most of the actions listed in other categories are likely to improve stream flow. • Protect springs	Rock Creek downstream of RM 19.2, lower Squaw Creek, upper watershed	Channel morphology, habitat diversity, key habitat quantity, fine sediment, flow, water tempera-ture, thermal refugia, altered food web	Road and grazing management, channelization	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve water quality, reduce summer water temperatures	• Restore riparian vegetative cover with suitable native vegetation to increase shading • Restore natural habitat functions and processes through actions previously identified • Develop sediment control basins • Management livestock grazing in the riparian areas • Increase deep pool habitat	Rock Creek downstream of RM 19.2, lower Squaw Creek, upper watershed	Channel morphology, habitat diversity, key habitat quantity, fine sediment, flow, water temperature, thermal refugia	Road and grazing management,, particularly in riparian areas, channelization	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve and/or restore riparian function and condition	• Restore riparian vegetation cover with appropriate native vegetation • Manage grazing in riparian areas • Eradicate invasive plant species from riparian areas • Relocate beaver to suitable areas	Rock Cr. Below unnamed trib. at RM 19.2, Luna Gulch, lower Squaw Cr.	Hydrology, channel stability, fine sediment, water quality, key habitat quantity, habitat diversity, riparian vegetation	Road and grazing management activities	All life stages	abundance, productivity, spatial structure and diversity	0-50 years
Improve and/or restore channel structure and complexity	• Introduce LWD and other structure in stream as appropriate • Improve riparian vegetation to provide future source of LWD • Stabilize and protect stream banks • Fertilize streams with fish carcasses	Rock Creek downstream of RM 19.2, lower Squaw Creek, headwater streams	Channel morphology, habitat diversity, key habitat quantity, fine sediment, flow, water temperature, thermal refugia, altered food web	Road and grazing management, channelization	All life stages	abundance, productivity, spatial structure and diversity	0-50 years

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
Improve and/or restore floodplain function and channel migration processes	• Reconnect floodplain habitats • Reconnect side channels • Increase role and abundance of wood and large organic debris in streambeds • Relocate floodplain infrastructure, roads; improve maintenance, rehabilitate, decommission as appropriate • Remove dikes • Relocate beaver to suitable areas	Rock Cr. Below unnamed trib. at RM 19.2, Luna Gulch, lower Squaw Cr.	Channel morphology, habitat diversity, key habitat quantity, riparian vegetation, fine sediments, flow, water temperature	Road and grazing management activities	Juvenile rearing stage	abundance and productivity	0-10 years
Address upland processes to minimize unnatural rates of erosion and runoff	• Restore native upland plant communities • Implement upland management practices to restore natural runoff and sediment production • Implement off-road vehicle management actions that reduce erosion and fine sediment • Implement road management actions that reduce fine sediment inputs	Upper watershed	Hydrology, channel stability, fine sediment, water quality, key habitat quantity, habitat diversity, riparian vegetation	Road and grazing management activities and off-road vehicles	Egg, fry	abundance and productivity	0-50 years
Review and reduce effects of harvest on the Rock Creek steelhead population	• Review the need for modifications to sport, tribal, and commercial harvest practices on direct catch and by-catch • Increase outreach efforts to reduce the number of steelhead caught in recreational fisheries near the mouth of Rock Creek	All fishing areas in the basin, the Columbia River, and off-shore	Direct mortality	Harvest	Adult migrants	abundance	0-10 years
Research and reduce hatchery effects on the Rock Creek steelhead population	• Reduce the uncertainty of origin of hatchery strays and increase ability to recognize hatchery-origin fish • Monitor the potential for hatchery strays entering Rock Creek • Increase the proportion of	Columbia River and anadromous reaches of Rock Creek	Competition, genetic introgression	Hatchery releases	Juvenile and adult	abundance, spatial structure, diversity	2-10 years

Strategy	Actions	Action Area	Potential Limiting Factors Addressed	Threats Addressed	Life Stages Potentially Affected	VSP Parameters Addressed	Expected Biophysical Response[1]
	Columbia River Basin hatchery steelhead marked with coded-wire tags, especially in programs shown to stray at high rates in the past, and support the mass marking of all hatchery steelhead releases with, at a minimum, an adipose fin-clip						
Reduce competition with and predation by non-native piscivores	• Reduce the number of non-native predators	Columbia River and mouth of Rock Creek	Predation	Non-native species	fry and juvenile	abundance and productivity	2-20 years
Reduce mortality and/or improve passage at hydroelectric facilities	• Implement strategies and actions in the FCRPS Biological Opinion (NMFS 2008b)	Columbia River	Passage, predation, direct mortality	Hydroelectric plants	juvenile and adult	abundance	0-20 years

[1] Expected response of action implementation – including how long for action to achieve full effectiveness

[2] BLM=Bureau of Land Management, Ecology=Washington Department of Ecology, KC=Klickitat County, KCCD=Klickitat County Conservation Districts, NRCS=National Resources Conservation Service, Private=private landowners and businesses, TNC=The Natural Conservancy, WDFW=Washington Department of Fish and Wildlife, WRIA31 PU = WRIA 31 Planning Unit, YN=Yakama Nation, MNFS=National Marine Fisheries Service, ODFW=Oregon Department of Fish and Wildlife

7. Implementation and Cost Estimates

Implementation of this plan depends on the voluntary actions and cooperation of local entities and citizen groups. An important part of implementation will be working cooperatively to develop an implementation schedule that includes site-specific actions and a detailed research, monitoring, and evaluation plan addressing the information needs described in Chapter 8. As a regional collaborative structure begins to take shape, it has become clear that a detailed RM&E plan should be developed collaboratively after the Rock Creek recovery plan is adopted.

7.1 Implementation

NMFS has worked independently with the Yakama Nation, Washington Department of Fish and Wildlife, Klickitat County, and local entities to develop the recovery plan for the Rock Creek steelhead population. NMFS encourages the formation of a planning group for the Washington Gorge Management Unit, a forum or entity that would take responsibility for coordinating implementation of the plan. Implementing the proposed recovery actions for steelhead in the Washington Gorge Management Unit, including the Rock Creek subbasin, would be a primary task for a Washington Gorge Area Regional Board, subject to concurrence by state, tribal, and local governments and the opportunity for involvement and comment by the public.

The Board could consist of representatives from Klickitat, Yakima, and Benton counties, local landowners, and the Yakama Nation. The Washington Gorge Area Regional Board could also provide an opportunity for coordination with the Lower Columbia River Fish Recovery Board (LCFRB), since the Washington Gorge Management Unit encompasses both the Middle Columbia River Steelhead DPS, and the Willamette/Lower Columbia ESUs for Chinook, coho, and chum ESA-listed populations, which are covered by the LCFRB. The Board could prioritize recovery actions in the Rock Creek subbasin and other areas within the Washington Gorge Management Unit by developing one- and three-year implementation schedules that would build upon and respond to the interests of stakeholders in the area.

Setting priorities for projects for funding and developing an implementation schedule should be based on a balance between the biological benefit of the project, its cost, and feasibility of implementation. Projects that address primary limiting factors, have high biological benefit, are relatively inexpensive, and are feasible should receive highest funding priority. Projects that are costly, have low biological benefit to listed fish species, and have relatively low feasibility should receive lowest funding priority.

In addition to their co-management responsibility and key role on a Gorge recovery board (if one is formed), the Yakama Nation will play an important role during implementation because of their funding agreement under the Columbia Basin Fish Accords (Columbia Basin Accords 2008), which are three Memorandums of Agreement (MOAs) entered into between the Federal Columbia River Power System (FCRPS) action agencies (Bonneville Power Administration, U.S. Army Corps of Engineers and the Bureau of Reclamation),

four tribes, and one state. The most relevant MOA to the Middle Columbia River steelhead is with the Columbia River Inter-Tribal Fish Commission and the three treaty fishing tribes—Confederated Tribes of the Umatilla Indian Reservation; Confederated Tribes of the Warm Springs Reservation; and Confederated Tribes and Bands of the Yakama Nation. The MOAs are 10-year action agency commitments for projects to benefit fish affected by the FCRPS, with a focus on ESA-listed fish. The projects will be reviewed through the Northwest Power Act processes for implementing the Fish and Wildlife Program, administered by the Northwest Power and Conservation Council. The agreement secures approximately $200,000 per year for habitat actions, including project management, in the Rock Creek subbasin. Some of the projects listed in Table 7-1 will be implemented with these funds.

7.2 Costs

There are existing Federal, tribal, state, county and other local programs that are being carried out in the Rock Creek subbasin. Many of those programs, for example the USDA NRCS Conservation Reserve Enhancement Program, the Washington State Forest Practices regulations and county plans and ordinances are described in Appendix II. This plan assumes that those existing programs are funded, and will continue to be. At this time, this plan provides only additional incremental costs that would be incurred with implementation of this recovery plan. Total time and cost of recovery is estimated for the DPS as a whole and is iincorporated into Chapter 8 of the Middle Columbia River Steelhead DPS Recovery Plan. As implementation proceeds and implementation schedules are developed, the costs of both existing programs and new incremental costs of this recovery plan will be included in those schedules. If existing programs are not funded, funding will be identified as a need in the implementation schedule and the cost estimates for the recovery plan adjusted accordingly.

In an earlier iteration of this recovery plan, rough, preliminary estimates were also made for the data gathering actions described in Chapter 8 as part of the recovery strategy. The preliminary estimate for RM&E was reported at that time as $3,350,000 over 10 years. As described above, NMFS is not going to incorporate this cost estimate at this time; rather, we expect those costs to be developed as part of a collaborative effort to design an RM&E plan.

In this chapter, cost estimates are provided for an extensive and reach-specific set of potential habitat actions that will be refined and prioritized in the implementation process. NMFS, in coordination with the Yakama Nation, developed these cost estimates for a range of habitat improvement/restoration actions that may be necessary to address limiting factors and improve viability of the Rock Creek steelhead population. These costs, presented in Table 7-1, are general range summaries. Habitat action costs for recovery over a 10-year time period are estimated to be up to $1.8 million ($0.9 million for years 1-5). The actions listed in Table 7-1 do not include or account for RM&E (Section 6.1.1), because those costs will be developed as part of implementation planning, nor do they account for tributary fishery harvest management and enforcement activities (Section 6.1.4), which are considered existing programs, nor for costs of out-of-subbasin effects, which are addressed through other programs (Section 6.1.6).

The list of actions in Table 7-1 was developed primarily to address habitat limitations in each major reach of Rock Creek. The actions are a primary component of the restoration and habitat enhancement strategy discussed in Section 6.1.3 of this plan. Costs were assigned to key actions such as riparian plantings with native vegetation, removal of exotic vegetation, fencing exclosures, and the installation of root wads and other instream structures. These labor-intensive actions will increase shading, resulting in an improvement to water quality and a restoration of riparian function and channel structure and complexity. Several water and sediment control basins will also be installed to assist in the removal of cattle from sections of the stream with an anticipated improvement of riparian condition. An additional major strategy is to protect and conserve existing good quality habitat (Section 6.1.2), through such actions as purchase of conservation easements or land acquisition from willing sellers. Table 7-1 includes costs for acquisition and easement estimates provided by personnel of The Nature Conservancy who have been involved with easements and acquisitions in the Rock Creek watershed. Although each easement and acquisition negotiation is unique, NMFS believes these values to be the best available estimate for such actions within the Rock Creek subbasin.

Table 7-1 Costs Associated with Proposed Reach-Specific Actions for Rock Creek Provided by Yakama Nation Fisheries.

	Rock Creek Actions and Costs				
	** = Utilized Oregon NRCS 2006 Conservation Practice Component Cost List* *# = Utilized Fiscal Year 2006 Montana NRCS Conservation Practices Cost List*				
Reach	**Action**	**Unit**	**Unit Cost**	**# Units**	**Cost**
RC1 – Rock Creek, mouth to boat ramp at RM 1.1	Due to reach's complete inundation by John Day Pool, only dam operation and reservoir actions can affect reach.				
RC2 – Rock Creek, boat ramp to Old Highway 8	Fencing #	per foot	1.4	2120	2968
	Riparian planting #	per tree	11	2890	31790
	Offsite water *	Each	1500	2	3000
	Instream structures (rock weir etc) *	Each	2000	8	16000
	Revetment #	per bank linear foot	10	350	3500
	Rootwad #	Each	600	15	9000
	Exotic vegetation removal	per acre	1000	10	10000
RC3 – Rock Creek, Old Hwy. 8 to Squaw Cr.	Bioengineered channel stabilization next to road	per foot of channel	47	400	18800
	Fencing #	per foot	1.4	46464	65049.6
	Riparian planting #	per tree	11	3468	38148
	Offsite water *	Each	1500	4	6000
	Instream structures (rock weir etc) *	Each	2000	7	1400
	Revetment #	per bank linear foot	10	400	4000
	Rootwad #	Each	600	15	9000
	Water and sediment control basin *	Each	3000	4	12000

	Rock Creek Actions and Costs				
	** = Utilized Oregon NRCS 2006 Conservation Practice Component Cost List* *# = Utilized Fiscal Year 2006 Montana NRCS Conservation Practices Cost List*				
	Exotic vegetation removal	per acre	1000	4	4000
SQ1 – Squaw Cr., mouth to Harrison Cr.	Fencing #	per foot	1.4	47520	66528
	Riparian planting #	per tree	11	1445	15895
	Offsite water *	Each	1500	4	6000
	Instream structures (rock weir etc) *	Each	2000	6	12000
	Revetment #	per bank linear foot	10	150	1500
	Rootwad #	Each	600	8	4800
	Water and sediment control basin *	Each	3000	5	15000
	Exotic vegetation removal	per acre	1000	2	2000
SQ2 – Squaw Cr., Harrison Cr. to White Cr.	Fencing #	per foot	1.4	33792	47308.8
	Riparian planting #	per tree	11	1445	15895
	Offsite water *	Each	1500	3	4500
	Instream structures (rock weir etc) *	Each	2000	6	12000
	Revetment #	per bank linear foot	10	150	1500
	Rootwad #	Each	600	4	2400
SQ3 – Squaw Cr., White Cr. to extent of distribution	Fencing #	per foot	1.4	31680	44352
	Riparian planting #	per tree	11	1445	15895
	Offsite water *	Each	1500	3	4500
	Instream structures (rock weir etc) *	Each	2000	6	12000
	Revetment #	per bank linear foot	10	200	2000
	Water and sediment control basin *	Each	3000	5	15000
	Rootwad #	Each	600	4	2400
HA1 – Harrison Cr., to extent of distribution	Fencing #	per foot	1.4	22176	31046.4
	Riparian planting #	per tree	11	1445	15895
	Offsite water *	Each	1500	2	3000
	Instream structures (rock weir etc) *	Each	2000	4	8000
	Revetment #	per bank linear foot	10	150	1500
	Rootwad #	Each	600	4	2400
RC4 – Rock Cr., Squaw Creek to Imrie Property Bridge	Spring protection	per site	800	3	2400
	Dike removal	Cubic yard	8	10800	86400
	Fencing #	per foot	1.4	27456	38438.4
	Riparian planting #	per tree	11	1445	15895
	Offsite water *	Each	1500	2	3000
	Instream structures (rock weir etc) *	Each	2000	8	16000

	Rock Creek Actions and Costs				
	** = Utilized Oregon NRCS 2006 Conservation Practice Component Cost List* *# = Utilized Fiscal Year 2006 Montana NRCS Conservation Practices Cost List*				
	Revetment #	per bank linear foot	10	300	3000
	Rootwad #	Each	600	8	3200
	Exotic vegetation removal	per acre	1000	6	6000
RC5 - Rock Creek, Imrie Property Bridge to Luna Gulch	Spring protection	per site	800	4	3200
	Dike removal	Cubic yard	8	4500	36000
	Fencing #	per foot	1.4	10560	14784
	Riparian planting #	per tree	11	1445	15895
	Offsite water *	Each	1500	1	1500
	Instream structures (rock weir etc) *	Each	2000	6	12000
	Revetment #	per bank linear foot	10	200	2000
	Rootwad #	Each	600	8	3200
	Exotic vegetation removal	per acre	1000	8	8000
LG1 - Luna Gulch: Rock Creek to Extent of Distribution	Fencing #	per foot	1.4	73920	103488
	Riparian planting #	per tree	11	3468	38148
	Offsite water *	Each	1500	7	10500
	Instream structures (rock weir etc) *	Each	2000	11	22000
	Rootwad #	Each	600	16	9600
	Water and sediment control basin *	Each	3000	7	21000
	Exotic vegetation removal	per acre	1000	8	8000
RC6 – Rock Cr., Luna gulch to Badger Gulch	Fencing #	per foot	1.4	24288	34003.2
	Riparian planting #	per tree	11	1445	15895
	Dike removal	Cubic yard	8	1080	8640
	Offsite water *	Each	1500	2	3000
	Instream structures (rock weir etc) *	Each	2000	5	11000
	Rootwad #	Each	600	8	4800
	Exotic vegetation removal	per acre	1000	2	2000
BG1- Badger Gulch	Water and sediment control basin *	Each	3000	4	12000
	Riparian planting #	per tree	11	1445	15895
RC7- Rock Cr., Badger Gulch to Unnamed Trib1	Fencing #	per foot	1.4	5280	7392
	Riparian planting #	per tree	11	1445	15895
	Instream structures (rock weir etc) *	Each	2000	3	6000
UN1 – Unnamed trib at Rock Cr. RM 19.2	Water and sediment control basin *	Each	3000	3	9000
	Riparian planting #	per tree	11	1445	15895
RC8 – Rock Cr., Unnamed Trib 1 to Quartz Creek	Fencing #	per foot	1.4	32736	45830.4
	Instream structures (rock weir etc) *	Each	2000	3	6000

	Rock Creek Actions and Costs				
	** = Utilized Oregon NRCS 2006 Conservation Practice Component Cost List* *# = Utilized Fiscal Year 2006 Montana NRCS Conservation Practices Cost List*				
	Rootwad #	Each	600	6	3600
QZ1 – Quartz Cr., mouth to small slide	Water and sediment control basin *	Each	3000	12	3600
	Riparian planting #	per tree	11	2890	31790
QZ3- Quartz Cr., small slide to Box Canyon	Water and sediment control basin *	Each	3000	10	3000
	Riparian planting #	per tree	11	2890	31790
QZ4 – Quartz Cr., Box Canyon to Extent of Distribution	Water and sediment control basin *	Each	3000	14	42000
	Riparian planting #	per tree	11	2890	31790
	Instream structures (rock weir etc) *	Each	2000	6	12000
BX1 – Box Canyon, mouth to Box Canyon falls	Water and sediment control basin *	Each	3000	10	30000
	Riparian planting #	per tree	11	2890	31790
RC9 – Rock Cr., Quartz Creek to Small Fall	NO ACTIONS				
RC11 – Rock Cr., Falls to Super Slide	Water and sediment control basin *	Each	3000	6	18000
	Riparian planting #	per tree	11	2890	31790
	Instream structures (rock weir etc) *	Each	2000	4	8000
RC13- Rock Cr., super slide to small slide	Water and sediment control basin *	Each	3000	6	18000
	Riparian planting #	per tree	11	2890	31790
	Instream structures (rock weir etc) *	Each	2000	5	10000
RC15 – Rock Cr., slide to Triple Falls	Water and sediment control basin *	Each	3000	8	24000
	Riparian planting #	per tree	11	2890	31790
General	NRCS Conservation Reserve Program	Cost per acre	41.60	6000 annually	249600
General	Conservation Easements	Cost per acre	450	50 annually	22500
General	Land Acquisitions	Cost per acre	600	50 annually	30000

8. Monitoring, Research, and Adaptive Management

Comprehensive, empirical monitoring data on fish populations and habitat are needed to identify appropriate projects and locations, populate habitat/production capacity modeling efforts (such as EDT, AHA, or other appropriate models), and inform adaptive management for the salmonid recovery plan. Information on fish distribution, abundance, productivity, habitat conditions, genetic diversity, pathogen levels, and other population parameters, as well as on population limiting factors, is necessary to help direct and evaluate these efforts. A coordinated monitoring program is needed to ensure that these various needs, including salmonid recovery planning, are met.

As part of implementing the Rock Creek steelhead recovery plan, a detailed monitoring and evaluation program will be collaboratively designed and incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS' guidance document, Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance (NMFS 2007a) http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf.

8.1 Adaptive Management

Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. It is a process of adjusting management actions and/or directions based on new information. It means taking an experimental approach to a complex task, making one's assumptions clear, and continuously evaluating them in light of new information. It works best when the collection of performance data and methods of evaluation are designed to get the information managers need to make sound decisions.

As outlined in the NMFS Adaptive Management guidance document, several types of monitoring are needed to support adaptive management: (1) implementation and compliance monitoring, which is used to evaluate whether the recovery plan is being implemented; (2) status and trend monitoring, which assesses changes in the status of an ESU and its component populations, as well as changes in status or significance of the threats to the ESU; and (3) effectiveness monitoring, which tests hypotheses and determines (via research) whether an action is effective and should be continued. (These three types of monitoring are discussed in more detail below.)

In addition, it is important to build in some research to illuminate the many unknowns in salmon recovery—the "critical uncertainties" that make management decisions all the harder. Critical uncertainty research may seem expensive or unnecessary in light of basic information needs; however, in the long run, it may reduce monitoring and implementation costs.

NMFS' guidance document presents a decision framework that can guide the design of a research, monitoring, and evaluation plan. The framework (Figure 8-1) contains two basic sorts of questions: (1) questions regarding ESU status (biological viability criteria)

and (2) questions regarding statutory listing factors and factors limiting recovery (limiting factor and threats criteria). Evaluating a species for potential delisting requires an explicit analysis of both types of criteria.

The guidance document contains a more detailed discussion of the framework and identifies the specific questions that should be answered to evaluate ESU status. These specific questions take the form of a series of decision-question sets that address the status and change in status of a salmonid ESU and the risks posed by threats to the ESU. The decision-question sets are designed to elicit the information NMFS needs to make delisting decisions. For recovery planners, the framework can guide future decisions about strategies and actions aimed at achieving recovery goals.

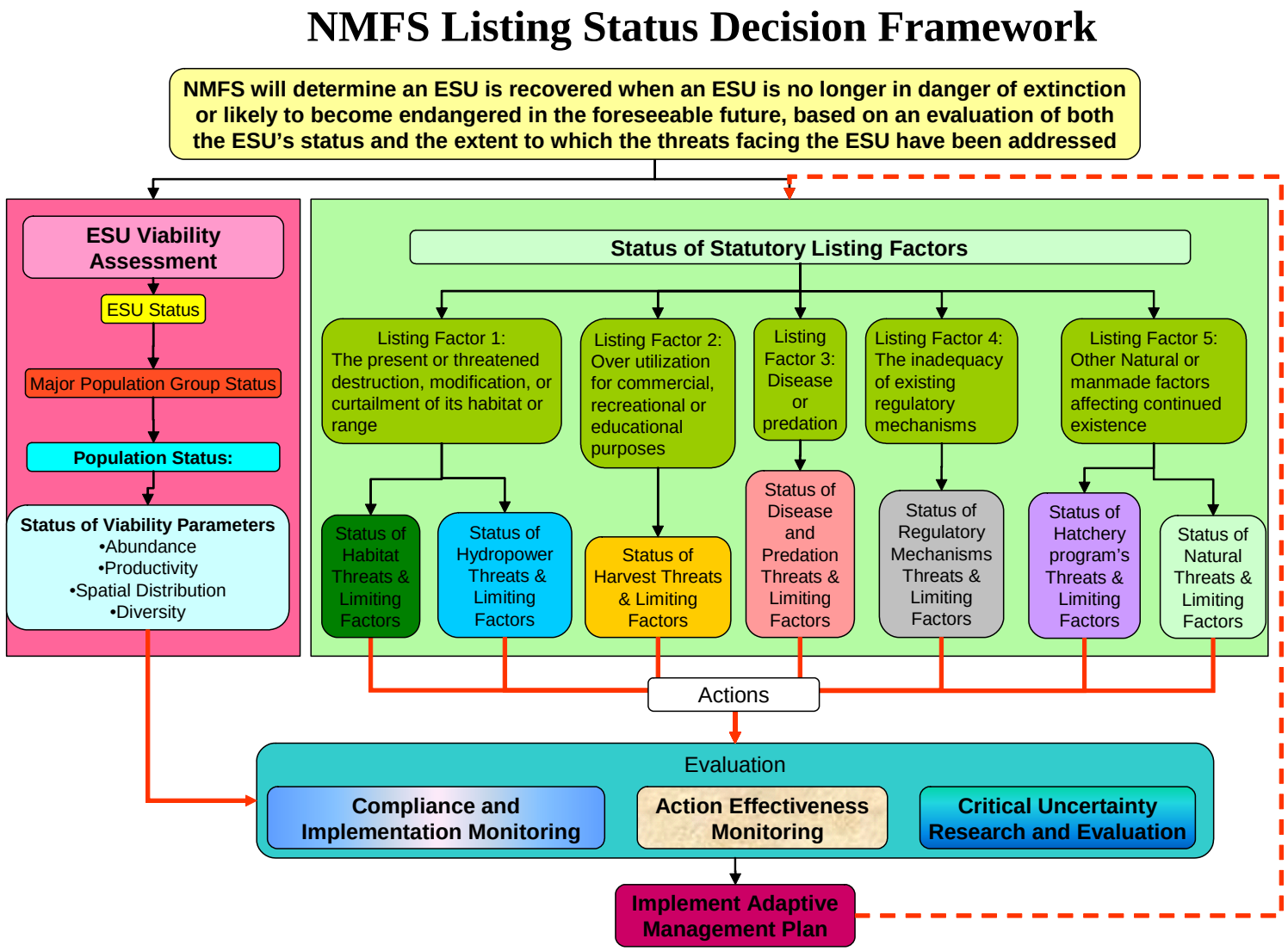


Figure 8-1 NMFS Listing Status Decision Framework.

8.2 Designing a Monitoring and Evaluation Program to Support Adaptive Management

Because of the length and complexity of the salmonid life cycle, there are many uncertainties involved in improving salmonid survival. Simply identifying cause-and-effect relationships between any given management action and characteristics of salmon populations can be a scientific challenge. It is essential to design a monitoring and evaluation program that will answer these basic questions: How will we know we are making progress? How will we get the information we need? And how will we use the information in decision making?

Designing an effective monitoring program for salmon recovery involves the following initial steps:

1. Clarify the questions that need to be answered for policy and management decision making. Include the full ESU and the full salmonid life cycle.
2. Identify entity or entities responsible for coordinating development of this program.
3. Identify:
    - Which populations and associated limiting factors to monitor
    - Metrics and indicators
    - Frequency, distribution, and intensity of monitoring
    - Tradeoffs and consequences of these choices
4. Assess the degree to which existing monitoring programs are consistent with NMFS guidance.
5. Identify needed adjustments in existing programs, additional monitoring needs, and strategy for filling those needs.
6. Develop a data management plan (See Appendix B of *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance (May 1, 2007)* http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf
7. Prioritize research needs for critical uncertainties, testing assumptions, etc.
8. Identify entities responsible for implementation.

The Rock Creek subbasin monitoring and evaluation program will build on existing programs designed for monitoring tributary habitat in the Rock Creek subbasin, hydropower actions in the Mid-Columbia, Mid-Columbia hatchery programs, and other actions outside of the Mid-Columbia tributary subbasins (e.g., Columbia mainstem hydropower, estuary and ocean conditions and salmon use, mainstem and ocean harvest). The Rock Creek monitoring and evaluation program will provide (1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed, (2) a plan for tracking such metrics and indicators, and (3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the Plan's goals.

8.2.1 Implementation and Compliance Monitoring

Recovery actions implemented within the Rock Creek subbasin will be monitored to assess whether the actions were carried out as planned. This will be carried out as an administrative review and will not require environmental or biological measurements.

Implementation and compliance monitoring simply check on whether activities were carried out as planned, and whether specified criteria are being met as a direct result of an implemented action.

Implementation monitoring will address the types of actions implemented, how many were implemented, where they were implemented, and how much area or stream length was affected by the action. Indicators for implementation monitoring may include visual inspections, photographs, and field notes on numbers, location, quality, and area affected by the action. For example, if a fence is planned for 20 miles of stream corridor to keep livestock off the stream-banks so that riparian vegetation will rebound, implementation monitoring would verify the presence of the fence. Compliance monitoring would take note of the presence or absence of livestock in the fenced-off area.

Success will be determined by comparing field notes with what was specified in the plans or proposals (detailed descriptions of engineering and design criteria). Thus, design plans and/or proposals will serve as the benchmark for implementation monitoring. Any deviations from specified engineering and design criteria will be described in detail.

8.2.2 Status and Trend Monitoring

Status and trend monitoring is a simple compilation of data-based descriptions of existing conditions. To be useful in decision making, the raw data, or metrics, should be reduced to a more directly applicable form or indicator. For example, if the question is "What is the annual spawning population size of steelhead in Rock Creek?" the indicator would be total spawning numbers of steelhead over one season for the entire river basin; however, the metric, or directly measured thing, would be something quite different, perhaps steelhead redds sighted on weekly passes over known spawning grounds. Thus, the metric should be processed to translate it from the metric data type (e.g., redds) into the indicator data type (e.g., spawners), and then reduced to generate the indicator required (e.g., list of weekly counts on spawning grounds to annual total for watershed).

A future collaborative Washington Gorge Area Regional Board could direct implementation and develop a program to monitor the status and trend of steelhead population viability attributes, their habitats and their associated limiting factors throughout the Rock Creek subbasin. In the event that a collaborative Board cannot be established, co-managers along with participating local entities and individuals would establish such a program to utilize and comport with the guidelines developed in the NMFS, "Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance", the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and the Collaborative, and the Systemwide Monitoring and Evaluation Project (CSMEP).

8.2.3 Effectiveness Monitoring

Effectiveness monitoring specifically addresses cause-and-effect questions. Demonstrating the direct and indirect impact of management actions requires supporting all steps in the logical chain that connects the action to its expected impact. This chain is rarely short and usually contains several hypotheses. For this reason, it's better to build the effectiveness monitoring into the recovery action strategies, with, for example, pilot-scale tests or other methods carefully thought out beforehand.

Effectiveness monitoring, tests hypotheses and determines (via research) whether an action is effective and should be continued. Effectiveness monitoring should be coordinated with implementation monitoring. Not all recovery actions recommended in this plan need to be monitored for effectiveness. However, it is important that a sufficient number of replicates of each "type" of action be assessed for effectiveness. To the extent possible, effectiveness monitoring of recovery actions should be coordinated with the Washington's effectiveness monitoring program and should be monitored using the Before-After-Control-Impact (BACI) design with stratified random sampling, as described in the Comprehensive Statewide Monitoring Strategy (Monitoring Oversight Committee 2002). This strategy describes in detail the approach, indicators, and protocols needed to assess effectiveness of habitat restoration classes.

Monitoring and evaluation will only provide the answers to the questions they were designed to address; they do not provide the framework for revising these questions if they are ill-posed, evaluating the assumptions upon which the strategy was built, or incorporating learning into future decisions on actions and strategies—this is the role of adaptive management. Further guidance on effectiveness monitoring and validation monitoring/research can be found in NOAA's "Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance."

8.3 Research and Critical Uncertainties

Critical uncertainties, the unknown aspects of environmental conditions vital to salmonid survival, are a major focus of the research, monitoring, and evaluation program. Critical uncertainties fall into several categories policy, legislation, and science. The RM&E will focus primarily on the scientific uncertainties.

8.3.1 Out-of-Subbasin Uncertainties

There are numerous uncertainties regarding out-of-subbasin factors affecting the Rock Creek steelhead population. Successful recovery of steelhead as defined by the regional recovery plan requires achieving specific levels of productivity for populations within the entire DPS, not only acceptable productivity within any single basin that is a part of the DPS. This means that local communities in different watersheds/basins across local and state boundaries are dependent upon each other for successful delisting of these species. Results of actions, monitoring and research associated with NOAA's Estuary Module and 2008 FCRPS Biological Opinion should be coordinated with an appropriate local collaborative Board.

8.3.2 In-Subbasin Uncertainties

Monitoring is needed to establish linkages between specific actions and resultant environmental effects. Those linkages are complex and often not well understood. Understanding them requires input from experts from various fields. It is important that the actions recommended in the Plan to benefit listed fish species in the Rock Creek subbasin be reviewed by fish ecologists, geologists, hydrologists, and other experts familiar with the recovery region to determine how uncertainties may affect the interpretation of results.

Specific benchmark values for the VSP parameters will likely be refined during plan implementation based on new information. The following are examples of questions/research that would significantly enhance the ability to answer the information gaps or other relevant questions by providing new information to reduce uncertainty. These ideas and concerns could be discussed and prioritized during collaborative development of an RM& E plan.

- Conduct surveys to determine steelhead distribution.
- Gather information to calculate abundance and productivity estimates.
- Evaluate population phenotypic and genetic variation.
- Identify major life history strategies.
- Conduct studies to address genetic variation in the population.
- Assess the contribution of hatchery-origin steelhead to the natural spawning opulation.
- Document the 'spawner' contribution/distribution throughout the subbasin.
- Determine the number of Rock Creek steelhead caught in various fisheries.
- Evaluate the importance of 'straying' as a mechanism of maintaining the population.
- Determine survival from egg to fry.
- Further evaluate limiting factors and their causes.
- Evaluate what can be done to reduce stream temperature (Aspect Consulting 2005; Glass 2009).
- Evaluate what can be done to enhance stream flow (Aspect Consulting 2005; Glass 2009).
- Implement genetic research to identify genotypic variation, help establish presence of winter and summer runs in Rock Creek.
- Increase understanding of linkages between physical and biological processes so that managers can predict changes in survival and productivity in response to selected recovery actions.
- Validate the EDT model for Rock Creek with up-to date information, conduct sensitivity analyses for the model, and test assumptions built into the Rock Creek model runs.
- Determine relative performance (survival and productivity) and reproductive success of naturally produced steelhead in the wild.
- Assess population structure.

- Assess steelhead distribution in neighboring subbasins and determine genetic relationship to Rock Creek steelhead population
- Determine the effects of exotic species on recovery of steelhead and the feasibility of actions to eradicate or control numbers of exotic species.
- Evaluate increased predation risks from native and non-native fish and birds.
- Assess eutrophication and aquatic vegetation impacts and determine ecologically sound solutions to address the problems near the mouth of Rock Creek.
- Assess potential of conserving and rehabilitating springs.
- Identify what current water temperatures in the lower river are, and whether fish can survive with higher average mainstem temperatures if in-stream and side channel/floodplain habitats are intact, diverse and provide thermal refugia.

8.4 Existing Monitoring and Research

Many entities have been or will be implementing recovery actions within and downstream from the Rock Creek subbasin. Monitoring programs with which to coordinate include:

- WRIA 31 Watershed Monitoring Program (Klickitat County, EKCD, and the Washington Department of Ecology).
- Yakima Klickitat Fisheries Project,
- Yakama Nation Monitoring,
- NOAA Fisheries RME Program,
- Washington Salmon Recovery Funding Board Program,
- PACFISH/INFISH Monitoring Program,
- Pacific Northwest Interagency Regional Monitoring Program,
- USFWS, USGS, and BOR Monitoring Programs,
- WDFW and Department of Ecology monitoring programs, and
- Local Conservation District monitoring.

It is critical that these programs be consulted to emphasize utility, reduce redundancy, increase efficiency, and minimize costs.

8.5 Additional Needs

Additional monitoring needs may be identified in the future and should be incorporated into the RM&E plan during development or through the implementation of the adaptive management process.

8.6 Data Management

A formal and documented approach to data management is essential to adaptive management. A well-designed data management plan can help to ensure that data of a specified quality and quantity is available, at a specified time, to meet specified data analysis needs. Protocols, metrics, and other data standardization tools such as common data entry methods are a top priority for recovery plans. Coordination across existing monitoring programs and projects will be underpinned by an integrated monitoring and

data management framework. The framework would, for example, require the use of common methodologies for sample design, data collection, data validation, and data sharing in order to address common questions. Data management systems should be developed and coordinated with national and regional efforts for consistency with regional and national data standards. Project implementation data management should be consistent with PCSRF protocols where appropriate and guidance from PNAMP's effectiveness work group. Further guidance on data management is provided in the NMFS Guidance document Adaptive Management for Salmon Recovery.

It may be appropriate to incorporate data management with the Yakima Klickitat Fisheries Project, the WRIA 31 Watershed Management Plan implementation (and the WRIA 31 initiating governments), and other regional programs to provide easy comparison with existing large datasets within the DPS. There may be some administrative obstacles to this, but efficiency would dictate that this is likely the most appropriate resource. Storage of new monitoring information and access to existing information will be under contract with the local implementation body of this plan.

8.7 Consistency with Other Monitoring Programs

This recovery plan will utilize existing monitoring programs to evaluate the status/trend and effectiveness of recovery actions within the Rock Creek Basin. Specifically, this approach should incorporate strategies, indicators, and protocols described in the WRIA 31 Watershed Management Plan, the Upper Columbia Monitoring Strategy, the Comprehensive Statewide Monitoring Strategy, and Collaborative Systemwide Monitoring and Evaluation Project (CSMEP). The development of other regional monitoring programs may result in modifications to the monitoring programs used in the Rock Creek basin. These other programs, in various states of development, include such approaches as Pacific Northwest Aquatic Monitoring Partnership (PNAMP). As these programs develop more fully, they will provide guidance on valid sampling and statistical designs, measuring protocols, and data management. This information may be used to refine and improve the existing monitoring and evaluation programs in the Rock Creek basin. The intent is to make monitoring and evaluation programs in Rock Creek consistent with programs throughout the ESUs/DPSs and Columbia Basin.

8.8 Coordination

Many entities have been or will be implementing recovery actions within and downstream from the Rock Creek Basin. Monitoring programs to coordinate with include:

- NOAA Fisheries RME Program,
- Washington Salmon Recovery Funding Board Program,
- PACFISH/INFISH Monitoring Program,
- Pacific Northwest Interagency Regional Monitoring Program,
- USFWS, USGS, and BOR Monitoring Programs,
- WDFW and WDOE Monitoring Programs,
- Local Underwood Conservation District Monitoring, and
- WRIA 31 Implementing Governments.

It is critical that these programs be consulted to emphasize utility, reduce redundancy, increase efficiency, and minimize costs.

8.9 Evaluation Schedule

The Rock Creek subbasin currently has no collaborative regional Board guiding and coordinating recovery implementation. Tracking progress or needs for adaptive management in the Rock Creek subbasin by evaluating information from the recovery plan's research and monitoring programs would be one of the roles of a Washington Gorge Area Regional Board. Appropriate time intervals and triggers/goals need to be established to evaluate project implementation, compliance and effectiveness; the status (and change in status) of a population's viability attributes; the status of a population's limiting factors; and the research needs identified in the recovery plan.

On an annual basis, the Washington Gorge Area Regional Board would review efforts within the Rock Creek subbasin to determine whether funding has been obtained and actions initiated. Further evaluations should occur at intervals coordinated with other subbasin in the DPS. Reviews at this time should start with funding and implementation effectiveness. If funding and implementation have taken place previously, their effectiveness should be reviewed and progress toward the overall implementation of projects within Rock Creek should be measured. Status reviews should be coordinated with NOAA Fisheries five-year status reviews. Progress, or the lack thereof, should be evaluated within context of the entire DPS. In the absence of a Washington Gorge Area Regional board, monitoring efforts would probably continue to be coordinated/implemented through two programs -- Yakama Nation Fisheries, and, WRIA 31 Watershed Planning under Chapter 90.82 RCW, which coordinates state and local efforts.

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Appendix I. Eastern Tributaries in the Washington Gorge Management Unit

Appendix I describes steelhead distribution and current conditions in several small tributaries to the Columbia River that drain areas in eastern Washington State upstream of Rock Creek. These tributaries are included in the Washington Gorge Management Unit of the Middle Columbia River steelhead DPS, which also contains the Rock Creek subbasin. There is very little information available about these small eastern Washington tributaries. NMFS considers them lower priority at this time than restoring the core populations of the Middle Columbia steelhead DPS. These drainages do not have enough historical habitat potential to sustain minimum numbers of spawners over a long time. If there are steelhead present, which has not been established in all cases, the ICTRT believes that the long-term occupancy of these small, relatively isolated streams probably depends on straying from a variety of areas, with the nearest upstream populations likely being the largest contributors of strays.

A summary of the available information is included as an Appendix to the Rock Creek Plan simply to acknowledge that these tributaries are part of the Washington Gorge Management Unit and that some insight into these areas might be useful to scientists and stakeholders in the future.

Introduction

NMFS defined "management units" for salmon and steelhead recovery planning based on jurisdictional boundaries as well as areas where local recovery planning efforts were underway. Several small eastern Washington tributaries of the Columbia River that drain lands to the east of the Rock Creek watershed are included in the Washington Gorge Management Unit and are considered part of the Middle Columbia River steelhead DPS. The management unit includes the White Salmon, Klickitat, and Rock Creek subbasins as well as the following small tributaries to the east: Chapman Creek, Wood Gulch, Pine Creek, Alder Creek, Glade Creek, and Fourmile Canyon (Figure ApI-1).

The Interior Columbia Technical Recovery Team (ICTRT) included these small eastern Washington State tributaries in the independent population boundaries of the Willow Creek and Umatilla populations of the Middle Columbia River steelhead DPS, which were historically the closest upstream independent populations (Figure ApI-1). The Willow Creek population is now considered extirpated (ICTRT 2009).

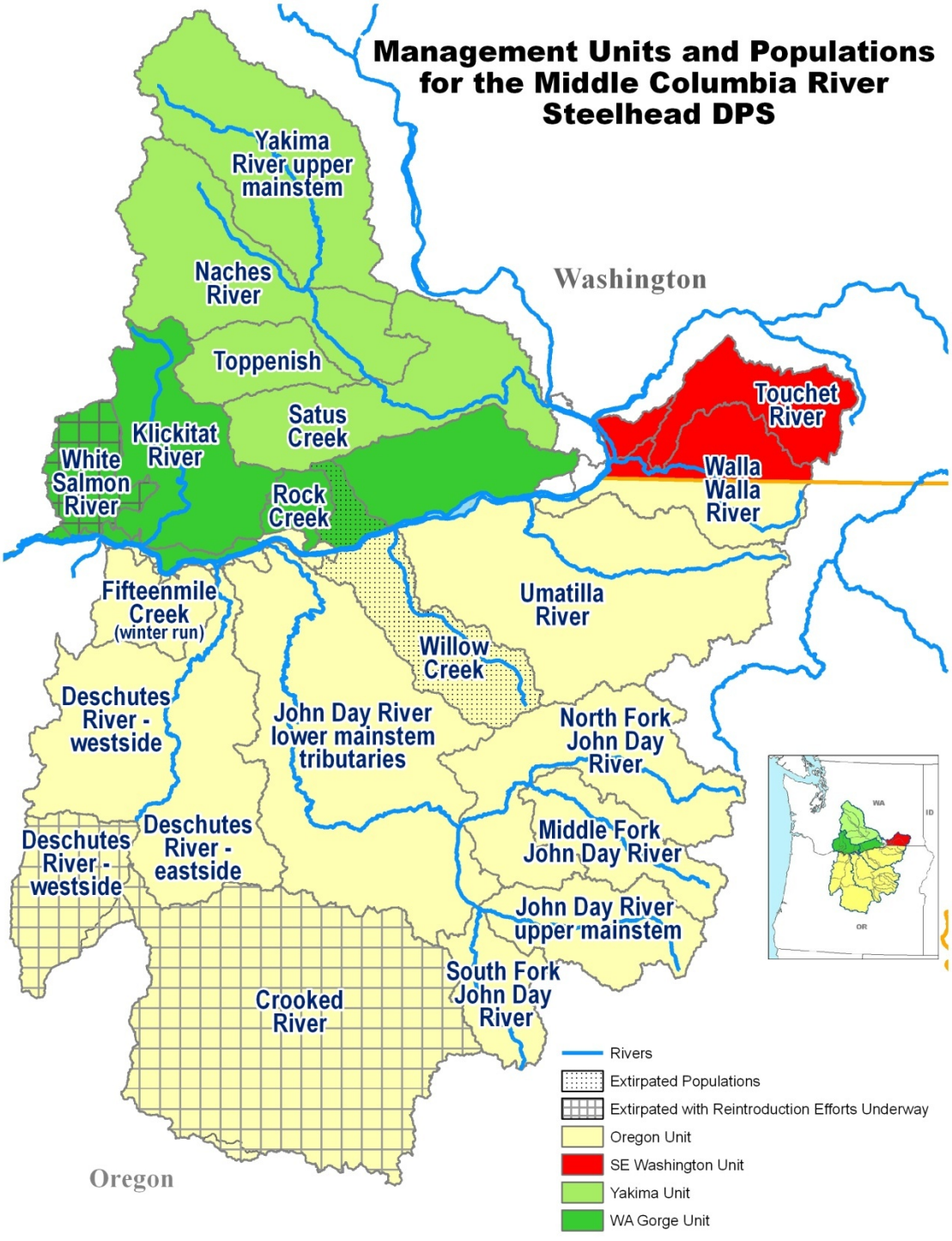


Figure ApI-1 NMFS Management Units for the Middle Columbia Steelhead DPS

The Umatilla and Willow Creek populations are part of the Oregon-Washington bi-state Umatilla/Walla Walla major population group (MPG) of the Middle Columbia River steelhead DPS. The Umatilla/Walla MPG includes three extant populations and one extirpated population. The Umatilla population is classified as a large population, and the other two, the Walla Walla and the Touchet, are classified as intermediate in size. The Umatilla population spawns primarily in Oregon, the Walla Walla population in both Oregon and Washington, and the Touchet population entirely in Washington. The Middle Columbia Steelhead DPS Recovery Plan (NMFS 2009) and the Oregon Middle Columbia River Steelhead Recovery Plan (Carmichael 2009) target the Umatilla population for viability and provide viability criteria, status assessment, limiting factors and threats, strategies and actions for recovery of the Umatilla population. The Willow Creek population is extirpated, and it is not considered to be a potential contributor to recovery of the DPS (NMFS 2009).

The small eastern Washington tributaries do not have enough historical habitat potential to sustain minimum numbers of spawners over a long time. If there are steelhead present, which has not been established in all cases, the ICTRT believes that the long-term occupancy of these small, relatively isolated streams probably depends on straying from a variety of areas, with the nearest upstream population likely being the largest contributor of strays. For that reason, the ICTRT included Alder Creek, Glade Creek, and Fourmile Canyon in the Umatilla population, and by the same logic inferred that steelhead (if any) in Chapman Creek, Wood Gulch, Pine Creek, and Old Lady Canyon historically could have been related to the now-extirpated Willow Creek population. It is unlikely that any current production in those small tributaries on the Washington side reflects Willow Creek. It is much more likely that any current production in those streams is either ephemeral, or linked with a currently producing upstream tributary (e.g., the Umatilla), or the result of straying from other extant steelhead populations/hatchery programs (ICTRT 2003, ICTRT 2009, and Tom Cooney, pers. comm. 2009).

Recovery Goal

NMFS' goal is for the Middle Columbia River Steelhead DPS to be recovered and removed from listed status under the ESA. Biological goals and criteria for the recovery of steelhead populations and MPGs in the Middle Columbia River steelhead DPS were developed by the ICTRT (2009) and described in the Middle Columbia Steelhead DPS Recovery Plan.

According to ICTRT viability criteria (ICTRT 2005, ICTRT 2007a, ICTRT 2007b), the Umatilla/Walla Walla MPG and other MPGs in the DPS should be at low risk (viable) for the Middle Columbia River steelhead DPS to be considered viable. ICTRT criteria recommend, and the Middle Columbia River Steelhead DPS Recovery Plan provides, that for the Umatilla/Walla Walla MPG to be regarded as viable:

1. Two of the historical populations in the MPG should meet at least minimum viability standards.
2. Viable populations within the MPG should include one large and one intermediate sized populations.
3. All major life history strategies present historically should be represented.
4. One population should be highly viable.

5. All populations that do not meet viable status should be maintained.

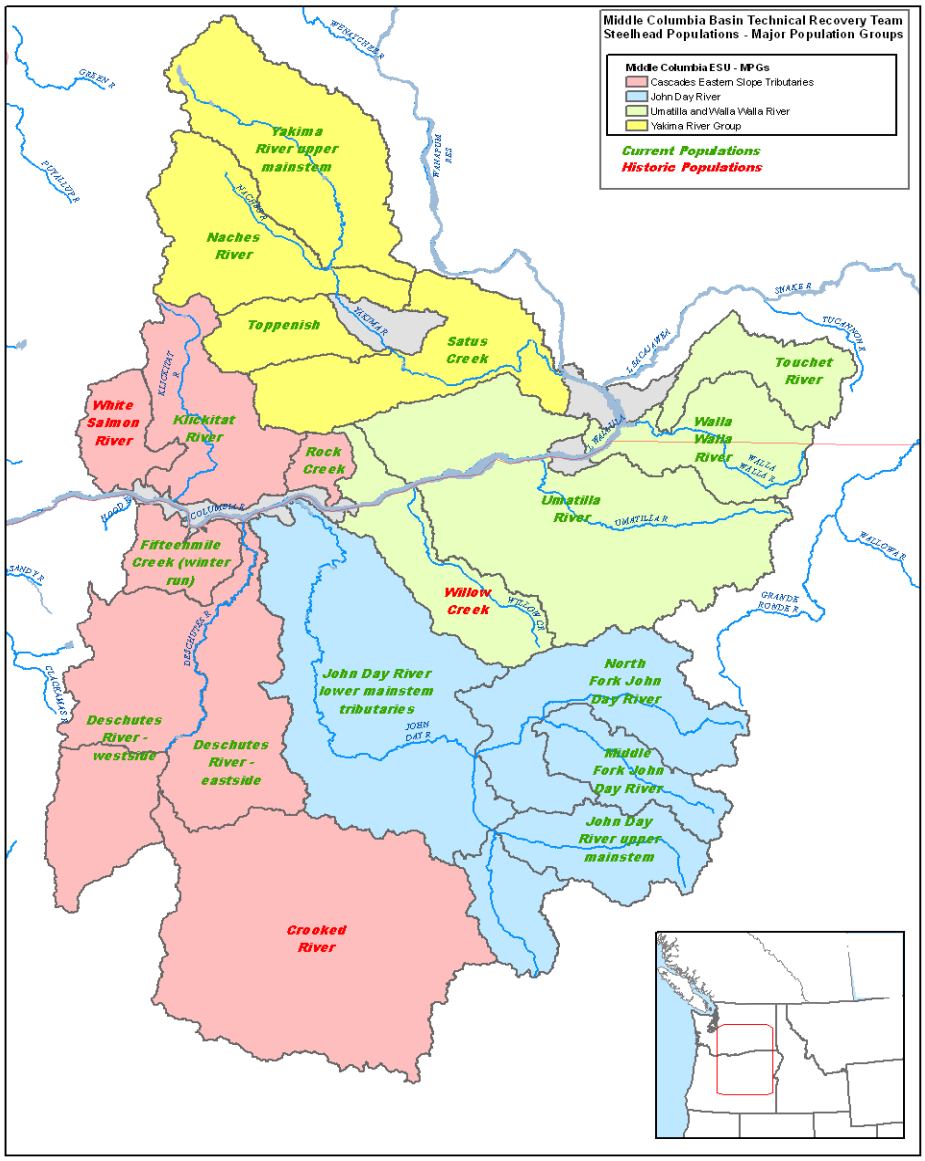


Figure ApI-2 NMFS Populations and Major Population Groups for the Middle Columbia River Steelhead DPS.

To meet the MPG-level viability criteria for the ESA, the Umatilla population should be at least viable (less than 5 percent extinction risk), or highly viable (less than 1 percent extinction risk). Either one of the intermediate populations, the Touchet or Walla Walla, should also reach viable or highly viable status. The remaining extant population should have no more than a 25 percent extinction risk. The Willow Creek population is considered extirpated and is not currently included in the ICTRT's recommended recovery scenario for the Umatilla/Walla Walla MPG (ICTRT 2005, ICTRT 2007a).

Because the Umatilla is a large population, the ICTRT recommended that to be viable, it should reach a minimum abundance threshold of 1,500 naturally produced spawners with a sufficient intrinsic productivity to achieve a 5 percent or less risk of extinction over a 100-year timeframe (ICTRT 2009).

The ICTRT considered Alder Creek, Glade Creek, and Fourmile Canyon to be spawning areas for the Umatilla River steelhead population, and included them in the assessment of spatial structure/diversity for that population (Section 6.1.9 in Carmichael 2009, and ICTRT 2009). However, these small tributaries were not included in the abundance/productivity rating because the Umatilla River drainage contains sufficient intrinsic potential habitat by itself to meet the definition of a large population. The Umatilla drainage is the core production area for the population (ICTRT 2009).

The Umatilla population does not currently meet the recommended viability criteria because its abundance/productivity and spatial structure/diversity risk ratings are both moderate. It does meet criteria for a "maintained" (moderate risk) population.

Recovery strategies and actions for the Umatilla population aim to improve viability by implementing actions to:

- Coordinate between planners, scientists and those implementing recovery actions in Washington and Oregon for sequencing, monitoring and adaptive management.
- Protect and improve freshwater habitat conditions and access for steelhead production. Improvements to freshwater habitat should be targeted to address specific factors in specific areas as described in the Southeast Washington Plan (SE Washington Management Unit Plan) and the Oregon Steelhead Recovery Plan (Oregon Management Unit Plan).
- Improve hatchery management to reduce straying from out-of-DPS hatchery fish onto natural spawning grounds within the Umatilla/Walla Walla subbasins.
- Improve survival in mainstem and estuary through actions detailed in NMFS Estuary Module (NMFS 2007) and FCRPS Biological Opinion (NMFS 2008).

Summary of Existing Information on the Eastern Washington Tributaries

The eastern tributaries that are part of the Umatilla/Walla Walla MPG fall within Washington's Middle Columbia River Salmon Recovery Region, which comprises salmon-bearing streams in Benton, Kittitas, Yakima, and parts of Chelan and Klickitat counties. They are in the state's Rock-Glade Water Resource Inventory Area (WRIA) 31, which is bounded on the south and east by the Columbia River, on the west by the Klickitat River subbasin, and on the north by the Simcoe Mountains and a basalt ridge of the Horse Heaven Hills. They flow in a southerly to southeasterly direction to Lake Umatilla, the portion of the Columbia River impounded by the John Day Lock and Dam. Elevations range from 200 feet at the confluence of Rock Creek and the Columbia River to over 4,000 feet in the Horse Heaven Hills (WSCC 2005).

Wood Gulch and Pine Creek drain an area of Washington State that is dominated by extensive basalt flows having a total thickness of up to 5,000 feet. The erosion-resistant nature of these flows has resulted in the creation of deep (500 to 800 feet), steep-walled canyons and has severely constrained floodplain development along substantial portions of the streams within this area (Aspect Consulting and WPN 2004). Chapman, Alder, Glade, and Fourmile Creeks flow over deep deposits of loess (Aspect Consulting and WPN 2004). Steep-walled canyons are common in these creeks as well because the underlying loess is highly erosive.

The streams appear to have similar geomorphic characteristics. Headwater tributaries flow out of the mountains and across the relatively flat basalt plateau at gradients of generally less than 1 percent; this area is above known anadromous use. Coming off the plateau, streams enter steep-walled canyons; gradients increase to 2 – 4 percent or more. Below the canyon reaches, most of the streams enter alluvial valleys; gradients range between 1 percent and 2 percent near the upper end, dropping to less than 1 percent as streams approach the Columbia.

Climate over the area is typical of that found on the east side of the Cascades; average daily temperatures range from 70°F in the summer (with maximums commonly above 90° F) to 37° F in the winter. Annual precipitation ranges from 14 to 16 inches in the eastern portion of upper Wood Gulch to less than 10 inches over the eastern two-thirds of the area. Most of the precipitation in the area falls between October and April (Aspect Consulting and WPN 2004). Cultivated agriculture is a more dominant land use in those subbasins with deep deposits of loess, including the lower halves of Alder, Glade, and Fourmile Creeks. A large portion of the cultivated land is irrigated in the southern halves of Glade Creek and Fourmile Creek, and to a lesser extent in the Alder Creek tributaries (Aspect Consulting and WPN 2004).

All these streams may have temperature problems: high water temperatures are recorded during summer months. Data suggest that water temperatures in Chapman Creek, Alder Creek, Wood Gulch and Pine Creek have been found to exceed the Washington Department of Ecology standard (17.5°C/63.5°F) (BLM 1986, EKCD 1997, Lautz 2000).

The ICTRT (2007) used regression models based on available stream temperature-elevation data to characterize reach-specific temperature regimes. The ICTRT cautioned that those projections reflect the factors driving stream temperatures during the periods of observation and are not necessarily representative of historical conditions. However, they used temperature mapping, based on those relationships, to identify populations and areas that are subject to relatively high stream temperatures during key rearing (and spawning) periods. Glade Creek and Fourmile Canyon are temperature-limited areas that could potentially have had temperature limitations historically. Alder Creek appears to be only partially temperature limited (ICTRT 2009).

Land use in Wood Gulch and Pine Creek subbasins is largely rangeland. While there is some dryland farming in these subbasins, the subbasins have shallow soils overlying aged basalts and are not well suited for cultivation. Cultivated agriculture is a more dominant land use in those subbasins with deep deposits of loess, including the lower halves of Chapman, Alder, Glade, and Fourmile Creeks. A large portion of the cultivated land is irrigated in the southern halves of

Glade Creek and Fourmile Creek, and to a lesser extent Alder Creek, subbasins (Aspect Consulting and WPN 2004).

Alder Creek

Alder Creek encompasses an area of 199.09 sq. miles (127,418.3 acres). Very little information is available regarding habitat conditions or steelhead distribution in the basin. The lower portion of Alder Creek is perennial as a result of spring water inputs and, in the lower half of the subbasin, irrigation return flow. Despite relatively dense riparian vegetation along the narrow creek, stream temperatures in the summer tend to be warm, with seven-day average temperatures possibly exceeding the state standard. Hill slopes of Sixprong Creek, a tributary to Alder Creek, were found to be up to 50 feet in height, nearly vertical, and of highly erosive material. The stream channel is well-defined in much of the Sixprong Creek, except in the lowest reaches, which contain broad wetlands. Government Land Office (GLO) land survey notes of the late 1800s indicate the steep canyon slopes were present at the time of early settlement (Aspect Consulting and WPN 2004).

Steelhead distribution: No surveys of fish distribution have been completed in the basin. Steelhead adults have reportedly been observed in the lower 1.5 mi. of Alder Creek (Yakama Nation Fisheries, unpublished information).

Habitat Conditions: Geology in the basin is dominated by flood deposits and loess (Aspect Consulting and WPN 2004). The loess is derived from wind-blown sediments and does not contain the gravels and cobbles necessary to form spawning habitat; therefore, there may be little spawning gravel present in the basin.

Glade Creek

The Glade Creek watershed covers 432.7 square miles on a wide, open, largely treeless, gently south-sloping plateau in southeastern Washington known as the Horse Heaven Hills. The majority of the watershed, including the lower half of mainstem Glade Creek, the eastern tributaries of Moore Canyon, East Branch Glade Creek, and Carter Canyon, lies in western Benton County, while the main branch of Glade Creek and Coyote Canyon extend across the northeastern corner of Klickitat County and into the southeast corner of Yakima County. Glade Creek's headwaters drain the east-west trending crest of the Horse Heaven Hills at elevations that range from 3,560 feet at the western end to 1,420 feet. East Branch joins the main branch of Glade Creek at an elevation of 365 feet; the confluence of Glade Creek at the Columbia River is at 266 feet above sea level (Garrigues 1996).

Annual precipitation is typically under 10 inches (Aspect Consulting and WPN 2004). About 90 percent of the precipitation falls between November and April, primarily as snow (Packard et al. 1994).

The Glade Creek watershed is underlain by at least 5,000 feet of basaltic flows forming three basalt formations, each composed of numerous, layered basalt flows with many potential fractured, water-bearing zones. Loess, alluvial, glaciofluvial and lacustrine deposits overlie the basalt and range from less than 5 feet to about 200 feet thick (Packard et al. 1994). Groundwater

flow direction in the watershed is determined to a large extent by geologic structure and topography, which combine to funnel groundwater flow toward the lower reaches of Glade Creek (Garrigues 1996). Groundwater recharge in the subbasin is estimated to be roughly 300 percent of pre-development conditions due to irrigation return flows (Aspect Consulting and WPN 2004).

Glade Creek and its tributaries are intermittent streams that, historically, have often been dry in the summer and autumn (Molenaar 1982; Davis 1993). Flow typically only occurs in the precipitation and snow-melt period, based on six crest-stage gauges on central Glade Creek and various tributaries and at a discharge measurement site at the creek's mouth (Molenaar 1982). Under normal precipitation conditions, nearly 100 percent of the flow in Glade Creek comes from baseflow (groundwater discharge), except during spring runoff and peak stream discharges after storm events (Garrigues 1996).

Crop production is the basis of the economy in the Glade Creek watershed. Dryland wheat occupies the greatest crop area, but irrigated lands have increased dramatically since the early 1970s (Packard et al. 1994) The principal groundwater use is for crop irrigation; however, the primary source of water used in the subbasin is surface water imported from the Columbia River (Aspect Consulting and WPN 2004).

Steelhead distribution: During a study conducted in spring of 2009, single pass snorkel surveys were conducted in Glade Creek. *O. mykiss* were not observed in Glade Creek (Glass 2009). Dace were the only species occupying the basin.

Habitat Condition: No suitable spawning habitat was found in the lower 2.5 miles of the stream (Glass 2009). The loess that dominates most of the basin is derived from wind-blown sediments and does not contain the gravels and cobbles necessary to form spawning habitat; therefore, it appears that the lack of spawning habitat is a natural condition. The available information regarding the naturally occurring lack of spawning habitat (Glass 2009) and absence of surface water flow throughout much of the basin (Garringues 1996) suggests that Glade Creek cannot support salmonid populations under naturally occurring conditions.

Fourmile Canyon

No information is available for Fourmile Canyon. A review of available aerial photographs indicate that Fourmile Canyon does not have an outfall into the Columbia or a tributary to the Columbia, suggesting that the canyon cannot support anadromous species (Glass 2009).

Chapman Creek

The Chapman Creek watershed encompasses 24.15 sq. miles (15,453.5 acres). The headwaters and other stream sections are dry for much of the year.

Steelhead distribution: No *O. mykiss* were observed in the one pass snorkel surveys conducted in Chapman Creek in October and November of 2008 (Glass 2009). Speckled dace were the only species observed utilizing habitats in the basin during the survey.

Habitat Condition: No suitable spawning habitat was found in the lower 4.5 miles of the stream, which includes the majority of the wetted area in late summer and fall. The loess which dominates most of the basin is derived from wind-blown sediments and does not contain the gravels and cobbles necessary to form spawning habitat; therefore, it appears that the lack of spawning habitat is a natural condition (Glass 2009). Due to the naturally occurring lack of spawning habitat, it is unlikely that Chapman Creek can support salmonid populations.

Wood Gulch Creek

Wood Gulch encompasses an area of 64.39 sq. miles (41,207.9 acres). The creek runs through a steep, arid canyon, with slopes that extend 500-800 feet up from the valley bottom. Precipitation in the basin ranges from 8 to 16 inches per year, falling primarily from October through April (Aspect Consulting and WPN 2004). The Wood Gulch fire burned 11,640 acres 2007, (www.wsp.wa.gov/fire/docs/mobilization/mobe_history_for_2008.pdf) including several stretches of riparian vegetation.

Human population is sparse in the subbasin. The primary land use in the subbasin is rangeland. Commercial-scale wind energy facilities are also present in the subbasin on the plateaus. Few roads traverse the basin, and most existing jeep trails are located at a distance from the stream, except a few which reach the valley bottom.

***O. Mykiss* distribution:** Single pass snorkel surveys were conducted in Wood Gulch in October and November of 2008 (Glass 2009). *O. Mykiss* were observed between river mile 1 and river mile 9. The majority (58 percent) of these fish were observed between river mile 1 and river mile 5. The proportion of the population that is anadromous is unknown. The size distribution of the *O. Mykiss* in the lower 5 miles of the stream is consistent with sizes expected of juvenile anadromous fish; however, the size distribution of the fish in the upper 4 miles of the fish distribution suggests that those fish may be part of a resident population because there were numerous larger fish (Glass 2009).

Habitat Condition: Twenty-four percent of the stream length surveyed in October and November of 2008 was dry. Dry segments were concentrated in the lower 1 mile of the stream (58.4 percent dry) and in segments upstream of approximately river mile 9 (68.7 percent dry) (Glass 2009). Based on GLO Land Survey notes from June 1867, Wood Gulch Creek was dry at the mouth and intermittent from there to the confluence of Big Horn Canyon, upstream of which perennial water seemed to return and extend to four miles upstream of the confluence with Big Horn Canyon, as well as 2-3 miles upstream into Big Horn Canyon (Aspect Consulting and WPN 2004).

The majority of the spawning habitat in the Wood Gulch basin is located in the lower 5 miles of the stream. The percent fines in the spawning gravels in fall and early winter of 2008 was less than 20 percent in most of the basin, indicating that the quality of spawning gravel was generally

good. Sixty-nine percent of the pool (rearing) volume identified in the surveys of 2008 was found in a 0.5 mile segment between river miles 8 and 9. Twenty-eight percent of the *O. mykiss* observed in the basin were found in this short stretch. The portion of the creek extending from river mile 1 to river mile 5 also contained numerous pools that represented 21 percent of the total pool volume in the basin. Fifty-eight percent of the *O. mykiss* observed in the basin were found in these pools (Glass 2009).

Pine Creek

Pine Creek is a small stream with a basin area of approximately 62.64 sq. miles (40,086.8 acres). Pine Creek feeds Lake Umatilla on the Columbia River upstream of John Day Dam in WRIA 31. Average subbasin elevation is 1904 feet; average annual precipitation ranges from 8 to 10 inches near the mouth to 14 to 16 inches in the headwaters of the basin (Aspect Consulting and WPN 2004)**.**

A system of five culverts at the SR 14 highway crossing of Pine Creek was included in the WSDOT Fish Passage Barrier Inventory as of March 2006. The intended entrance is fully submerged at approximately 30 feet depth in Lake Umatilla. The upstream invert of the pipes is several feet above the pool water surface much of the year. A large volume of sediment and debris has filled in the previous creek channel nearly 15 feet, and obstructs the entrance to the submerged culvert. Only a small opening clogged with woody debris passes flow from the stream through the road fill. The constricted culvert entrance has created a barrier to fish passage due to physical obstructions and high water velocities (Harbor Consulting Engineers 2007). The culvert was attributed with 0 percent fish passage by WSDOT (2006). The barrier culverts are slated for replacement in 2012.

***O. Mykiss* Distribution**: Due to the passage barrier at the mouth, all fish in Pine Creek are resident fish. They may have some genetic link to a previous anadromous population, but they are not currently an anadromous population.

The one pass snorkel surveys conducted in the lower 7 miles of the creek in November of 2008. Sixty-nine resident *O. mykiss* were observed distributed throughout the surveyed area (Glass 2009). Forty percent of the *O. mykiss* were observed in a single pool at roughly river mile 1 and thirty-two percent of the fish were observed in a single pool at roughly river mile 8.3. The remaining 19 percent of the fish were scattered throughout the lower 7 miles of the creek. Since *O. mykiss* were found throughout the survey area, additional fish may be present upstream of the surveyed area.

Habitat Condition: Within the area surveyed in November of 2008, 41.6 percent of the survey area was dry. Fifty-nine percent of the lower 5 miles of the stream was dry, but flow was more consistent further upstream where less than 10 percent of the channel length was dry (Glass 2009).

The majority of the spawning habitat in the surveyed portions of the Pine Creek basin is located between river mile 4 and river mile 8 (Glass 2009). The percent fines in the spawning gravels in November of 2008 was less than 20 percent in most of the basin, indicating that the quality of

spawning gravel was generally good. The total pool volume in the surveyed area was 182.1 cubic meters. Pool habitat was distributed throughout the survey area. Many of the pools in the lower 5 miles were isolated between dry stretches of channel.

Old Lady Creek

A brief reconnaissance of Old Lady Canyon was completed on 12/16/08, four days after a period of heavy rain (Glass 2009). The basin has several emergent wetlands. Despite the heavy rains, the stream was not flowing. The culverts under Highway 14 near the mouth of the basin is well positioned to carry any flow but were dry and clean suggesting flow occurs rarely, if at all.

Two vertical drops (no water) are along the apparent channel in the first reach of the basin; one is 17 feet high and the second is 16 feet high. There is a 21-foot interval between the two drops where a small depression 0.5 foot deep is present. Both drops would be upstream barriers to fish movement if flow were present in the canyon (Glass 2009).

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Appendix II. Current Efforts to Improve the Watershed

Many positive steps have already been taken or are currently underway that will improve steelhead habitat and overall watershed function in the Rock Creek drainage, and thus improve the viability of Rock Creek steelhead. The breadth of these efforts illustrates how natural resource managers, local governments, tribes, soil and water conservation districts, non-profit organizations, local land owners and many others are working together to improve watershed conditions that will support a viable Rock Creek steelhead population throughout its freshwater life stage. This appendix describes many of these efforts.

Conservation Efforts

- The Eastern Klickitat Conservation District (EKCD), under a 1996 Memorandum of Agreement with the Washington Department of Ecology, implemented actions to contribute to the protection of water quality, speed riparian recovery, and potentially prevent future flood-related damage in the Rock Creek drainage. In accordance with the MOA, the EKCD monitors water temperatures other water quality parameters (e.g., dissolved oxygen, pH, nitrates). This MOA, however, lapsed in 2004 and has not been renewed, but the EKCD continues to implement its provisions. The EKCD monitors water temperatures other water quality parameters (e.g., dissolved oxygen, pH, nitrates) as well as plant vegetation throughout the watershed. Under a grant from the Washington Conservation Commission (WCC), the EKCD "cost-shares" with landowners for grassland/permanent cover plantings and for no-till seeding throughout the Rock Creek drainage. Under a different grant from the WCC, the EKCD is working with livestock growers throughout the basin to develop and implement BMPs (Best Management Practices) which target restoration and protection of riparian areas (Jim Hill, EKCD District Manager, pers. comm. 2006).

- County governments, state and local agencies and other stakeholders/water resource interests developed a watershed plan under chapter 90.82 RCW for the Rock Creek Basin and elsewhere in Water Resource Inventory Area 31 (WRIA 31). WRIA 31 encompasses the Rock Creek subbasin and other Columbia River tributary systems between the John Day Dam and Kennewick in Washington State. A watershed assessment (http://klickitatcounty.org/NaturalR/Content.asp?fC=29&fD=3) was completed in support of the planning process (Glass 2009). The watershed management plan (http://klickitatcounty.org/NaturalR/Content.asp?fC=31&fD=3), which was approved in April 2009, will guide water resource and habitat management (WRIA 31 Planning Unit 2008). Chapter 90.82 RCW provides for plan implementation in the amounts of $100,000 for each of the first three years, and $50,000 for two additional optional years. The watershed management plan includes a list of prioritized habitat and water resource issues and a suite of

strategies to address those issues. Actions undertaken to date to implement the plan include ongoing stream flow monitoring by Washington Department of Ecology and completion of a quantitative instream habitat assessment for Rock Creek and several other streams in the WRIA.

- Washington's water quality and other water resource related funding programs administered by Washington Department of Ecology take local priorities and consistency with WRIA watershed plans into consideration when determining whether to fund proposed projects through grants and/or low interest loans. The WRIA 31 watershed planning unit serves as the body that develops the local statement of agreed priority for projects proposed within Rock Creek and other areas of WRIA 31.

- The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) works with landowners to conserve natural resources on private lands. The NRCS accomplishes this through various programs including, but not limited to, the Conservation Technical Assistance Program, Soil Survey Program, Conservation Reserve Enhancement Program, and the Wetlands Reserve Program. The NRCS works closely with local Conservation Districts; providing technical assistance and support.

- The Nature Conservancy has acquired land and conservations easements within the watershed. The Conservancy is working with Federal, state and private adjoining landowners to protect native habitats and significant plant and animal species, and to restore sites as functional ecosystems within the watershed.

- The Yakama Nation has provided basic monitoring and recently received a small grant to perform fencing and riparian plantings in lower Rock Creek. These actions will begin to address at a small scale the following limiting factors: loss of riparian vegetation, altered food web, altered channel morphology. A small grant was recently awarded the YN to conduct water quality/quantity measures, habitat surveys, and Ecosystem Diagnosis and Treatment (EDT) modeling in Rock Creek. Complementing this effort, the YN has proposed assessing Rock Creek's current and potential steelhead production by assessing the juvenile salmonid abundance, growth, life histories, and genetics. Data collected through assessment activities to determine steelhead distribution, diversity, relative abundance, and movement within or out of the watershed will help feed modeling efforts, which in turn will help prioritize restoration activities.

Regulatory Protection

Various state, tribal and county regulatory mechanisms are in place to protect riparian areas from current and future threats posed to listed species through habitat loss and degradation caused by human land uses and development. These mechanisms include Washington State forest and fish regulations, state and county shoreline development regulations and the Yakama Nation Forest Management Plan. In addition, some areas

receive special protection through designation, such as Wild and Scenic River reaches, primitive areas, and wildlife refuges.

Washington State Forest Practices Regulations

The Washington Forests & Fish Law (ESHB 2091) was signed into law in 1999 as part of The Washington State Forest Practices Act (Title 76.09 RCW), passed in 1974. The Forests & Fish Law, based on the Forests & Fish Report, resulted in changes to forest practices rules to protect riparian and aquatic resources on more than eight million acres of private forestland. It is intended to meet the provisions of the Federal Clean Water Act concerning nonpoint source silvicultural practices. Changes to the law included:

- Updates of the stream typing system in the state to improve mapping of fish-bearing waters,
- Increases in buffer widths along fish bearing and non fish bearing streams,
- Changes in forest practices to protect against landslides
- Mandatory requirements to update the forest road system to hydrologically disconnect roads from streams and minimize sediment delivered to streams,
- New regulations on pesticide applications to prevent or avoid drift of chemicals into streams,
- Increased protection of wetlands
- Changes in enforcement,
- Establishment of a scientifically based adaptive management and monitoring process for evaluating the impact of forest practices on aquatic resources,
- Establishment of a process for amending the forest practices rules to incorporate new information as it becomes available, and
- Establishment of a small landowner office to assist non-industrial landowners.

The Forest Practices Rules prescribe how forest practices such as logging, road building, and applying chemicals are to be conducted in ways that protect public resources. When operators or landowners do not follow the rules, the WDNR issues enforcement orders and may also issue a civil (monetary) penalty. A civil penalty is most often issued when the violation caused significant environmental damage, when an operator or landowner does not comply with the department's enforcement orders, or when the operator or landowner has a history of repeated violations. All civil penalties become final orders of the department unless appealed. Although violators are notified and/or fined, the infractions are usually addressed after they have already been committed, and the fines are often relatively insignificant compared to the value of the timber harvested.

Additional information regarding the Forest Practices rules can be found at: http://www.dnr.wa.gov/forestpractices.

The Washington Department of Natural Resources, on behalf of the State of Washington, submitted applications to NMFS and the U.S. Fish and Wildlife Service for incidental take permits under section 10 of the Endangered Species Act. Issuance of these permits would provide assurances that all forest practices activities in compliance with the state

forest practices rules and administrative program will satisfy ESA requirements for aquatic species. The two services released the final HCP, environmental impact statement (FEIS), and implementing agreement in a *Federal Register* notice on Jan. 27, 2006. This notice provides an opportunity for the public to review the final documents and the responses to public comments on the draft documents.

Klickitat County Shorelines Master Plan

The Klickitat County's Shorelines Master Plan (SMP) regulates "development" within the "shorelines" of Rock Creek and other water bodies in Klickitat County's jurisdiction. "Development" is broadly defined as: construction or exterior alteration of existing structures; dredging; drilling; dumping; filling; removal of any sand, gravel or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to the SMP regulations at any state of water level. "Shorelines" are those lands extending landward for 200 feet in all directions as measured from the ordinary high water mark, floodways and contiguous floodplain areas landward 200 feet from such floodways, and all wetlands and river deltas associated with the streams and lakes. The SMP applies to the shorelines of the main stem of the Klickitat River as well as the shorelines of all tributaries with a mean annual flow of 20 cfs or more.

The SMP designates various shorelines as "environments", which determine the level of protection that is warranted. Rock Creek is designated "Conservancy Environment", which allows a limited scope of development, subject to conditions (i.e. shoreline conditional use permit).

Each development proposal is subject to review pursuant to the shoreline environment within which it is to be located. One or more shoreline permits must be secured prior to implementation: Substantial Development Permits (SDPs) are required for any development for which the total cost or fair market value exceeds $5,000, or any development which materially interferes with the normal public use of the water or shorelines; Shoreline Conditional Use Permits (CUPs) are required for development types that warrant conditions to ensure consistency with the SMP; and Variances (VARs) are issued to grant relief from specific bulk, dimensional, or performance standards of the SMP in order to avoid unnecessary hardship, provided that extraordinary circumstances are shown to exist and the public interest shall suffer no substantial detrimental effect. Some types of development, such as a single-family residence, normal maintenance and repair, or construction of a normal protective bulkhead for a single family residence, are exempt from the requirement of a substantial development permit, but are still subject to all other provisions of the SMP.

Klickitat County's SMP was first adopted in the mid-1970s pursuant to the Washington State Shoreline Management Act of 1971, and has been updated periodically since then. Existing structures and developments that were established prior to adoption of the SMP are considered legally established "nonconforming" uses. Since adoption of the SMP, all developments within shorelines, including modifications to nonconforming uses, have

been reviewed by the County and Washington Department of Ecology (Ecology) to ensure compliance with the goals and requirements of the SMP.

The Department of Ecology reviews County permit decisions and has final authority to approve or deny conditional use permits and variances. Persons may appeal the final decision to the Shorelines Hearings Board.

Klickitat County Critical Areas Ordinance

Klickitat County adopted a Critical Areas Ordinance (CAO) in 2001 and, with the concurrence of Washington Departments of Fish and Wildlife, Community Trade and Economic Development, and Ecology, amended it in 2004. The CAO extends beyond the geographical scope of the County's SMP to protect wetlands, critical fish/wildlife habitat, geologically hazardous areas, aquifer recharge areas, and frequently flooded areas. The CAO is, in effect, an overlay on existing land use regulations. The CAO provides for standard setbacks of 300' from Category I wetlands; 200' from Category II; and 75' from Category III and IV. The CAO provides for standard buffers of 200' from Type 1 & 2 waters; 150' from Type 3 waters; 50' from Type 4 waters; and 25' from Type 5 waters. A wildlife habitat management plan is required for new development that will likely impair habitat functions and values. As with the SMP, developments and uses that existed prior to the adoption of the CAO are considered legally established "nonconforming" uses.

Klickitat County Floodplain Management Ordinance

The Klickitat County Floodplain Management Ordinance (FPO) regulates all development and activities that may increase flood hazards. A permit is required for development within areas of special flood hazard (with at least 1 percent chance of flooding). The applicant for a non-residential structure must include a certification and flood analysis conducted by a professional engineer. In general, development that will does not meet the specific criteria in the ordinance for development in these areas, to protect public health and safety, will be denied.

Klickitat County Zoning Ordinance

The Klickitat County Zoning Ordinance (CZO) was adopted in 1979 and has been amended over time. Much of the Rock Creek watershed is zoned by the CZO as "extensive agriculture" which requires a 20-acre minimum lot size for the purpose of dividing properties, and new development/uses are restricted to resource management uses/activities and other compatible uses. One permanent residential dwelling is allowed per lot. Some areas of the watershed are zoned for residential development. The allowable minimum lot size for new lots is either 1 or 2 acres; and one residential dwelling is allowed per lot. Other than residential development, most new development/uses in these zones is either prohibited or allowed per a zoning conditional use permit.

Klickitat County Environmental Ordinance (CEO)

The Klickitat County Environmental Ordinance (CEO) was adopted pursuant to the State Environmental Policy Act (SEPA). The CEO and SEPA require an analysis of probable significant adverse environmental impacts that may result from a proposed development. The CEO and SEPA require a threshold determination for each proposed development that is not exempt. The threshold determination is a determination that a project will or will not have probable significant adverse environmental impacts. If a project has probable significant adverse impacts, and environmental impact statement (EIS) is prepared. Any proposed development/use that is not specifically exempt in SEPA, chapter 43.21C RCW, or the SEPA rules adopted by the Department of Ecology, chapter 197-11 WAC, is required to comply with SEPA. Klickitat County provides applicable state agencies and tribes, as well as the public, the opportunity to review threshold determinations and EISs.

Washington State Water Pollution Control Act (Chapter 90.48 RCW)

This act gives Ecology the authority to protect water quality in the state and to promulgate regulations as needed to achieve this goal. The Act makes discharges of pollutants into waters of the state unlawful and has provisions for enforcement of violations, including the authority and process for issuing compliance orders and civil penalties, and for seeking criminal penalties. The Act also provides for permitting processes, cooperation with other entities, water quality monitoring, grants, and numerous other subjects regarding management of water quality issues in the state.

Washington's Statewide Monitoring Program

In 2001, Substitute Senate Bill (SSB) 5637 was signed into law. This act related to monitoring of watershed health and salmon recovery. The Monitoring Oversight Committee developed a comprehensive statewide strategy that addresses the actions identified in SSB 5637 (Monitoring Oversight Committee 2002). Among other things, the Plan is intended to provide information regarding trends in fish, water, and habitat conditions and assess effectiveness of actions taken to improve watershed health and provide for salmon recovery. The strategy includes documentation of fish population trends in some areas of the state; however, the Rock Creek Subbasin is not one of the areas included to date in that monitoring effort. The strategy is also monitoring the effectiveness of habitat restoration efforts funded by the State. The monitoring of project effectiveness follows the Monitoring and Evaluation Strategy that was developed by the Washington Salmon Recovery Funding Board in support of the Comprehensive Statewide Strategy. The Monitoring and Evaluation Strategy specified methods to assess a wide range of restoration and protection projects.

On-Site Sewage Systems

Chapter 246-272 of the Washington Administrative Code (WAC) regulates the on site disposal of sewage in the state. The law is applicable to septic systems as well as larger on-site systems. The rule addresses location of systems, site evaluations, design,

installation, inspection, operation and maintenance, repair, abandonment, and other areas of concern. The rule helps to prevent the discharge of sewage into fish-bearing streams.

Hydraulic Code

Chapter 75.20 RCW governs construction projects within the waters of the state. The law requires hydraulic project approvals from the Department of Fish and Wildlife for wharves, bulkheads, bridges, culverts, fish habitat restoration projects, and other construction activities within the ordinary high water mark. This regulation helps to protect fish and fish habitat during construction.

Regulation of Dairy Farms

Chapter 90.64 RCW, the Dairy Nutrient Management Act, includes a number of requirements designed to protect water quality from dairy operations. These are in addition to NPDES requirements in the Federal and State Clear Water Acts for concentrated animal feeding operations. The Act requires inspection of all dairy farms, implementation of dairy nutrient management plans, technical assistance and enforcement (including civil penalties) against significant polluters. The intent of the regulation is to protect water quality and, subsequently, fish habitat. Ecology is the primary regulatory authority under this Act.

Other Rules and Regulations

There are over 100 additional rules and regulations applicable to the protection of water quality and fish habitat in the State of Washington. These rules cover a broad range of subjects such as groundwater quality standards, application of pesticides, well construction, motor oil disposal, utilities, solid waste disposal and recycling, water supply facilities, mining, energy facilities, dikes and levies, aquiculture, etcetera. Lists of applicable laws and rules and links to the specific requirements of those laws and rules can be found at www.ecy.wa.gov/laws-rules.

Voluntary Programs

A number of voluntary programs have been developed to encourage landowners to implement conservation programs on their lands and to assist landowners with habitat improvement actions. Some of these programs are described below. The list includes only the larger programs. Other programs exist and new programs may be developed in the future that can be used to assist with conservation actions on private lands.

Lead Entity Process

In 1998 the Washington State Legislature enacted chapter 77.85 RCW to empower citizens at the community level to engage in salmon recovery through a locally driven habitat protection and restoration program. The legislation recognized that active local participation is the key to ensuring public participation in, and support for, salmon recovery. Through this legislation, local "Lead Entities" were identified and funded to implement chapter 77.85 RCW. Lead Entities prioritize projects for PCSRF funding administered by Washington State's Salmon Recovery Funding Board. A lead entity has

not been established for the Rock Creek subbasin, therefore PCSRF funds are not accessible at this time for habitat protection or restoration projects in the subbasin.

Conservation Reserve Enhancement Program (CREP)

The Conservation Reserve Enhancement Program is a voluntary program designed to establish forested buffers along streams where riparian habitat is poorly developed. Land enrolled in CREP is removed from production and grazing under 10 to 15-year contracts. In return, landowners receive annual rental, incentive, maintenance and cost share payments. The CREP program is administered by the Farm Service Agency and the State of Washington.

Conservation Reserve Program (CRP)

The Conservation Reserve Program provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands. The program encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover such as native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Farmers receive an annual rental payment for the term of a multi-year contract. The program is funded by the Farm Service Agency with technical assistance from the National Resource Conservation Service (NRCS).

Continuous Conservation Reserve Program (CCRP)

The Continuous Conservation Reserve Program is a voluntary program that protects soil, improves air and water quality, and enhances fish and wildlife habitat through the use of buffers, filter strips, and wind breaks. Contract periods range from 10 to 15 years. Cost shares and yearly payments are provided as incentives for participation in the program. The program is run by the Farm Services Agency.

The Grassland Reserve Program (GRP)

The Grassland Reserve Program is a voluntary program that helps landowners and operators restore and protect grassland, including rangeland, pastureland, shrubland, and certain other lands, while maintaining the areas as grazing lands. The program includes options for permanent or 30-year easements. Landowners receive payment for the easements. The Natural Resources Conservation Service (NRCS) administers the program in cooperation with the Forest Service.

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program was re-authorized by the 2002 Farm Bill to promote agricultural production and environmental quality as compatible national goals. The program is administered by NRCS. Management incentive payments and cost share benefits are available to support implementation of practices directly affecting the health of soils, water, animals, plants, and air.

The Conservation Security Program (CSP)

The Conservation Security Program is a voluntary program that provides financial and technical assistance to producers who practice good stewardship on their agricultural lands and incentive to those that want to improve or expand their conservation measures. Lands that can be placed into the program include cropland, pastureland, prairie, rangeland, and incidental forested land. The contract period and cost-share payments are based on a three-tier approach, with increasing compensation associated with increased natural resource protection. The program is run by the NRCS.

Wildlife Habitat Incentive Program (WHIP)

The Wildlife Habitat Incentive Program is a voluntary program that encourages creation of high quality wildlife habitats that support populations of National, State, tribal, and local significance. Through WHIP, the NRCS provides technical and financial assistance to landowners to develop upland, wetland, riparian, and aquatic habitat areas on their properties. Participants voluntarily limit future use of the land for a period of time, but retain private ownership. Agreements are usually five to ten years in duration.

The Healthy Forest Reserve Program (HFRP)

The Healthy Forest Reserve Program is a voluntary program established for the purpose of restoring and enhancing forest ecosystems to promote the recovery of threatened and endangered species, improve biodiversity, and enhance carbon sequestrations. The program offers three enrollment options including a 10-year agreement, a 30-year easement, and a longer term easement. The compensation to landowners increases with the term of the easement agreement. The program is administered by the U.S. Department of Agriculture and through the Conservation District.

Wetlands Reserve Program (WRP)

The Wetlands Reserve Program is a voluntary program that provides technical and financial assistance to landowners to address wetland, wildlife habitat, soil, water, and related natural resource concerns on private lands. The landowner receives financial incentives to restore, protect, and enhance wetlands or lands that have been historically modified for agricultural production in exchange for retiring marginal land from agriculture. Easements are either permanent or 30-year agreements. The NRCS administers the program.

Forestry Riparian Easement Program (FREP)

The Forestry Riparian Easement Program was developed to partially compensate eligible small forest landowners in exchange for a 50-year easement on timber that is required to be left under the forest practices rules. The landowner still owns the property and retains full access, but has “leased” the trees and their associated riparian function to the State. WDNR administers this program.

Yakama Nation Forest Management Plan

The Yakama Nation has voluntarily adopted the Yakama Nation Forest Management Plan, which is used to guide management of timber harvest and road construction and maintenance on tribal land.

Conservation Designations

Badger Gulch Natural Area Preserve

The Washington Department of Natural Resources (WDNR) established the 180-acre Badger Gulch Natural Area Preserve in 1982 to protect four important native plant communities and three rare plants. The Natural Area Preserve lies within Klickitat County about 6.8 miles north of the Columbia River and 13 miles east of Goldendale on the Goldendale-Bickleton road. The preserve includes a 2-mile long portion of Badger Gulch, a narrow, steep-walled canyon that contains Badger Creek, which empties into Rock Creek near RM 15. The four protected native plant communities (Idaho fescue, houndstongue hawkweed, Oregon white oak-ponderosa pine, bluebunch wheatgrass-Sandberg's bluegrass and white alder riparian) and three rare plant species (porcupine sedge, shining flatsedge, and beaked cryptantha) play an important ecological role in protecting the subbasin's water quality and many vertebrate and invertebrate species (WDNR 1998).

In 1998, Washington Department of Natural Resources' Southeast Region developed the "Badger Gulch Natural Area Preserve Management Plan." The purpose of the management plan is "to permit natural ecological and physical processes to predominate, while controlling activities that directly or indirectly modify these processes" on the preserve. The WDNR 1998 'Plan' defines all aspects of management for the site from public use to monitoring and research activities (WDNR 1998).

Klickitat Oaks Preserve

Adjoining the Badger Gulch Natural Area Preserve is The Nature Conservancy (TNC) of Washington's Klickitat Oaks Preserve. The current TNC Klickitat Oaks Preserve 414-acre site conserves/preserves native habitats and significant plant and animal species as a functional ecosystem within the upper Rock Creek watershed. This area has been a major conservation site for the TNC since the ecological significance of the area was identified in the 1980s. The Conservancy is currently negotiating the purchase of an additional 120-acre plot and, with another private landowner, a 1,500-acre limited development conservation easement. Working with Federal, state and private adjoining landowners, the TNC's purpose is to protect all of the native habitats and significant plant and animal species of the site as a functional ecosystem within the upper Rock Creek watershed.

The Nature Conservancy has developed an initial preserve design and an in-depth Site Conservation Plan for the area. The Nature Conservancy's conservation plan is a cooperative management strategy for the upper Rock Creek watershed involving the U.S. Bureau of Land Management, WDNR, and resident private landowners. The Nature

Conservancy has made a long-term commitment to the site and is currently involved in restoration and management work on the ground, including exotic species control, plant and animal inventory and assessment, and long-term restoration planning.

Appendix II References

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2009 YAKIMA STEELHEAD RECOVERY PLAN

Extracted from the

2005 Yakima Subbasin Salmon Recovery Plan

With Updates

Final
August 2009



Prepared by
the Yakima Basin Fish & Wildlife Recovery Board

Yakima Steelhead Recovery Plan

Extracted from the 2005 Yakima Subbasin Salmon Recovery Plan

with Updates

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EXECUTIVE SUMMARY

Introduction

The federal Endangered Species Act (ESA) requires listing species that have declined to the point that they are threatened with extinction and sets up regulations to protect these species. Recovering a listed species to the point that it no longer needs protection under the ESA is an important goal, both for people with a direct interest in the health of that species and for the individuals and groups who may be negatively affected by regulations put into place to protect a listed species. The ESA requires development of recovery plans that review a listed species' status, set recovery goals, and identify actions required to recover it and remove it from the list. Recovery plans are non-regulatory documents that provide guidance on how to recover a species; they do not create any binding commitments or legal mandates.

In 1999, the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) classified Middle Columbia River Steelhead as a threatened species under the ESA. In 2006, NOAA Fisheries revised its listing to apply only to the anadromous (ocean-going) form *of Oncorhynchus mykiss,* commonly known as steelhead.[1] This listing applies to steelhead that spawn in a large portion of central and eastern Washington and Oregon (See Figure 1.1). This document, the Yakima Steelhead Recovery Plan, is a recovery plan for those listed Middle Columbia Steelhead that spawn in the Yakima Basin and are collectively referred to as the Yakima Major Population Group (MPG).

This document is an updated version of the steelhead portion of the 2005 Yakima Subbasin Salmon Recovery Plan, which NOAA Fisheries approved as an interim recovery plan for Yakima Basin populations of the Middle Columbia Steelhead River Distinct Population Segment (DPS) in May 2006. This 2007 Yakima Steelhead Recovery Plan will be incorporated into NOAA Fisheries' Middle Columbia Steelhead Recovery Plan, which will be released in final form in the fall of 2009.

The Yakima Basin Fish & Wildlife Recovery Board developed this plan to guide steelhead recovery efforts in the Yakima Basin. The Board is a locally based organization governed by representatives of Yakima, Benton, and Kittitas counties, the Yakama Nation, and cities in the basin. The Board's mission is to "to restore sustainable and harvestable populations of salmon, steelhead, bull trout, and other at-risk fish and wildlife species through the collaborative, economically sensitive efforts, combined resources, and wise resource management of the Yakima River Basin." It is recognized by the State of Washington as one of the regional organizations at the heart of the state's salmon recovery efforts.

The Board and its partners followed guidance from NOAA Fisheries, Washington Department of Fish and Wildlife (WDFW) and the Washington Governor's Salmon

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[1] The freshwater-resident form of *O. mykiss* (commonly known as rainbow trout) is not listed, and falls under the jurisdiction of the U.S. Fish and Wildlife Service.

Recovery Office (GSRO) in developing this plan. Local planners also provided information and feedback to the Interior Columbia Technical Recovery Team (ICTRT) that NOAA Fisheries convened to develop science-based viability criteria and assessments of the status of steelhead populations. The ICTRT stock status assessments for Yakima Basin steelhead populations are incorporated into this document by reference.

This plan is built on the belief that healthy steelhead populations can be rebuilt in a manner that coexists with vibrant human communities and the local economies that support them. This plan emphasizes that steelhead recovery should build on existing fish and wildlife recovery programs and should rely on voluntary, non-regulatory approaches to habitat improvement. While this plan focuses on recovery efforts in the Yakima Basin, it acknowledges the need for ongoing recovery actions in the Columbia River, its estuary, and the Pacific Ocean. These are further addressed in NOAA Fisheries' Middle Columbia Steelhead Recovery Plan.

Recovery of steelhead in the Yakima Basin will not occur in a vacuum. In addition to steelhead, the basin once supported large populations of Chinook, coho, and sockeye salmon, oceangoing lamprey, and migratory bull trout. While only bull trout and steelhead are listed under the ESA, all of these species have declined significantly over the last 150 years. Recovering steelhead is just one objective of ongoing efforts to restore conditions that allow all of these species to thrive.

Chapter 1 provides more detail on the planning process and its broader context.

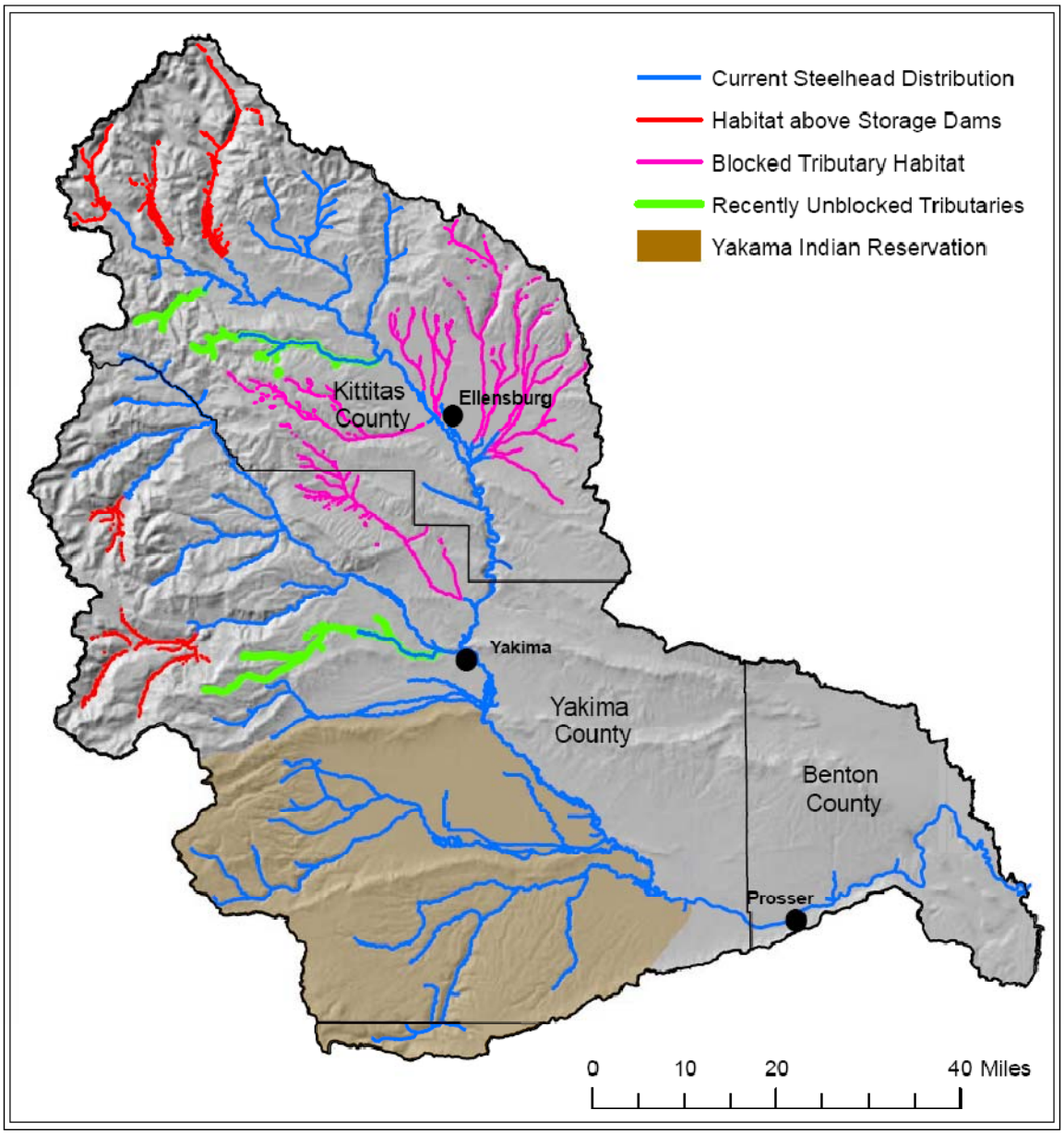
Species Status

Chapter 2 presents detailed empirical data about the status, distribution, characteristics, and life histories of Yakima Basin steelhead. Steelhead in the Yakima Basin are divided into four populations: the Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River populations. The NOAA ICTRT identifies the Satus Creek population as steelhead that spawn in the Satus Creek drainage on the Yakama Indian Reservation, the mainstem Yakima River below Satus Creek, and tributaries to the lower mainstem. For management purposes, local planners have subdivided the Satus population into the Satus block, which spawns in the Satus Creek drainage, and a mainstem block, whose current and historic status is uncertain. The Toppenish population consists of steelhead that spawn in Toppenish Creek, its tributaries and the short stretch of the mainstem between Toppenish and Satus creeks, and is entirely on the Yakama Reservation. The Naches population includes steelhead spawning in the Naches River and its tributaries (including the Tieton, Little Naches, American, and Bumping rivers and Cowiche, Rattlesnake and Nile creeks), the mainstem Yakima from the Naches confluence to the Toppenish Creek confluence and the tributaries to that reach of the Yakima, including Ahtanum Creek. The Upper Yakima population consists of all steelhead that spawn in the Yakima River and its tributaries upstream of the Naches confluence. Together these four populations make up the Yakima MPG.

Estimates of the number of adult steelhead returning to the Yakima Basin prior to European settlement range from 20,800 to 100,000. In contrast, the number of adults passing fish counting facilities at Prosser Dam (on the mainstem Yakima downstream of virtually all current spawning locations) between 1985 and 2006 has ranged from 450 to

4,491 with an average of 1,764. The ICTRT estimated the 10-year (1996-2005) geometric average by population as 379 for the Satus population, 322 for the Toppenish population, 472 for the Naches population, and 85 for the Upper Yakima.

Map A: Basin overview and status of steelhead habitat



The ICTRT modeled the extent of historically available steelhead habitat. This plan reviews that model, presents local planners revisions to the model, and compares that to current steelhead distribution (see Map A). Steelhead spawning is widely distributed throughout the areas accessible to them, except in the lower Yakima River and its tributaries (below the Satus Creek confluence). The extent and distribution of spawning

in the mainstem from the Columbia to Roza Dam is uncertain. Steelhead currently cannot access the watersheds above Tieton, Bumping, Cle Elum, Kachess, and Keechelus dams[2] and a number of significant tributaries (e.g., Wenas, Manastash, and Naneum creeks in the Upper Yakima population area, and until just last year, Cowiche Creek in the Naches population area).

The Yakama Nation and WDFW have emphasized maintaining the natural genetic composition of Yakima Basin steelhead stocks. The last release of hatchery-origin juvenile steelhead in the Yakima Basin occurred in 1993. Stray hatchery-origin fish from other basins made up only 3% of the run from 1999 to 2005.

Instead of dying immediately after spawning like most salmon, steelhead can survive, return to the ocean, and spawn again. The Yakama Nation is currently capturing post-spawning steelhead at Prosser Dam and reconditioning them in hatchery facilities to increase the number that survive to spawn again.

Our knowledge of steelhead status in the upper portions of the basin is complicated by the fact that steelhead and rainbow trout are different forms of the same biological species that can interbreed. Better understanding the historic, current, and future potential for steelhead production in these areas will require determining how habitat conditions, genetics, and survival rates for oceangoing smolts interact to affect the balance between resident and anadromous life histories.

The ICTRT assessed the viability of Yakima Basin steelhead populations and concluded that none currently meet its standards for viability. The Satus population comes nearest to meeting the ICTRT's standard, while the Upper Yakima population is farthest from the standard. The ICTRT analysis is based on NOAA Fisheries' Viable Salmonid Population (VSP) framework, which calls for managing salmon and steelhead populations based on an understanding of their abundance, productivity, spatial structure, and diversity.

Factors for Decline

Chapter 3 reviews the factors that led to the order of magnitude decline in abundance of steelhead in the Yakima Basin over the last 150 years. This decline parallels that of salmon throughout the Columbia Basin and is a function of both in-basin habitat changes, major impacts in the Columbia River and the Pacific Ocean associated with extensive harvest in fisheries, development of the Columbia River hydropower dams—Yakima steelhead must pass four on migrations to and from the sea—and management of hatchery programs in a manner that adversely affected wild populations.

Major in-basin factors for decline include:

1) Alteration of stream flows due to development of irrigation systems, including both the dewatering of lower reaches in many tributaries and the high and low flows in the mainstem Yakima and Naches rivers associated with water storage and delivery from upstream reservoirs

[2] The Bureau of Reclamation is currently evaluating passage options at the five storage dams.

2) Creation of passage barriers associated with both small and large diversion dams, road crossings, and Bureau of Reclamation (BOR) storage dams

3) Reductions in floodplain function due to diking, channel simplification, and floodplain development for agricultural and urban uses

4) Impacts to riparian areas and upland hydrology due to past and, to a lesser extent, current, grazing, and forestry practices

5) Changed ecological dynamics, including reduction in beaver populations, reductions in delivery of oceanic nutrients to headwaters by salmon, introduction of exotic species, and increased predation by native species

Significant progress has been made to address many of these threats, even as other threats have intensified because of changes in socio-economic conditions. Chapter 3 details the past and current status of these factors for each of the four populations (Satus, Toppenish, Naches, and Upper Yakima) and links them to the limiting factors framework used by NOAA Fisheries in the Middle Columbia Steelhead Recovery Plan.

Recovery Goals, Criteria, and Strategies

Chapter 4 identifies three different recovery thresholds for the Yakima MPG:

- An ESA de-listing threshold based on the ICTRT's framework that calls for one population to be viable, one to be highly viable, and two to be at "maintained status" or better

- A short-term recovery threshold that is based on the ICTRT framework, but emphasizes bringing all four Yakima populations to viable status

- A long-term recovery threshold that calls for restoring access to all historic habitat that can be restored consistent with the Board's commitment to sustaining local traditions and economies and improving abundance to levels that support broad ecological and harvest goals

The Board sees these three thresholds as points on a continuum. The Board concurs with NOAA Fisheries and the ICTRT that when the delisting threshold is met for the Yakima MPG and all other MPGs in the Middle Columbia River Steelhead DPS, it will be appropriate to consider removing the ESA listing. The Board expects recovery actions to continue after that point, even without the immediate motivation of the ESA. The long-term goals are less definite, but are meant to affirm that the Board and its partners believe that long-term recovery to significantly higher abundance levels is both feasible and desirable.

The abundance and productivity criteria associated with each of these thresholds are presented below. The delisting and short-term recovery criteria are drawn from the ICTRT viability analysis. Chapter 4 also sets out specific criteria for spatial distribution and diversity.

Abundance and Productivity Criteria

	Delisting Threshold		Short-Term Recovery		Long-term Recovery	
Population	**Avg. #**	**Prod.**	**Avg. #**	**Prod.**	**Avg. #**	**Prod.**
Satus: Satus Watershed Mainstem Block*	 500 500	 2.00 1.56	 500 500	 1.56 1.56	2,000	1.2 1.2
Toppenish	250	1.2	500	1.56	1,500	1.2
Naches	1,500	1.26	1,500	1.26	5,400	1.2
Upper Yakima	500	1.2	1,500	1.26	7,700	1.2
Total	***3,250***		***4,500***		***16,600***	

*Either spawners in the lower mainstem, or additional spawners above targets in other population areas, as described in Chapter 4

Achieving recovery goals for the Satus Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Continuing ongoing efforts by the Yakama Nation to improve watershed and riparian conditions within the Satus drainage
3) Restoring floodplain function and channel complexity in lower Satus Creek
4) Improving migration conditions in the mainstem Yakima River

Achieving recovery goals for the Toppenish Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Significantly improving passage, flows, and riparian conditions in Toppenish Creek and its tributaries
3) Restoring floodplain function in lower Toppenish Creek
4) Improving migration conditions in the mainstem Yakima River

Achieving recovery goals for the Naches Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat
2) Significantly protecting and improving passage, flows, and instream and riparian conditions in tributaries (Ahtanum, Bumping, Cowiche, Rattlesnake, Nile, and Little Naches watersheds)

3) Addressing the effects on steelhead of reservoir operations and irrigation withdrawals in the Tieton, lower Bumping, and lower Naches rivers

4) Improving floodplain function and conditions in the mainstem Naches River

5) Improving migration conditions in the mainstem Yakima River

Achieving recovery goals for the Upper Yakima Population will require implementing these strategies:

1) Continuing efforts to protect existing functional habitat

2) Providing unimpeded passage for steelhead in key tributaries (Manastash, Taneum and, if feasible, Naneum and Cle Elum)

3) Improving outmigration conditions at Roza Dam

4) Addressing the effects of reservoir and irrigation system operations on winter/spring/fall low flows and summer high flows in the lower Cle Elum and mainstem Yakima rivers

5) Protecting and enhancing floodplain conditions along the mainstem Yakima

6) Improving flows and instream and riparian conditions in tributaries and side channels

7) Improving migration conditions in the lower mainstem Yakima River

Recovery Actions

Chapter 5 identifies 94 steelhead recovery actions. These are broken into basinwide actions (16), Lower Mainstem Yakima actions (9), Satus Creek actions (8), Toppenish Creek actions (10), Naches actions (32), and Upper Yakima actions (21). These actions implement the strategies described above.

Implementing some or all of the set of actions presented here should significantly improve the abundance, productivity, spatial structure, and diversity of steelhead in the Yakima Basin. Recovery planners anticipate that the full suite of actions presented here, if combined with expected improvements outside of the Yakima Basin, will be more than sufficient to meet de-listing and short-term recovery goals, but that additional actions may be needed to reach long-term broad sense recovery goals.

The scope and level of detail of specific actions varies considerably. The Yakima Basin Fish & Wildlife Recovery Board is committed to working with partners who will implement recovery actions to refine action descriptions and develop a more specific implementation schedule.

Initial cost estimates for implementing all of the actions identified in this plan over 15 years total $1,168.3 million, with $269.3 million of that cost directly attributed to steelhead recovery. The remaining portion of the total cost is attributed to other sources based on anticipated benefits to agricultural producers (e.g. irrigation system improvements), flood control, open space, other fish and wildlife species, etc. This is a

simple and very preliminary estimate of actual implementation costs for actions. It is not a cost-benefit analysis of the proposed actions and does not include indirect costs such as opportunity and compliance costs associated with recovery efforts. It should not be taken as the total cost of recovery, as achieving delisting goals may require only implementing some of the actions included in this plan, while long-term recovery may require additional actions not included in the plan.

Plan Implementation

This plan is a beginning, not an end. Chapter 6 describes how this plan will be implemented. Achieving recovery goals will require sustained long-term efforts by a wide range of stakeholders. Salmon recovery is not a new pursuit in the Yakima Basin. Fish screening efforts began in the early 20th century, and intensive recovery efforts have been ongoing since the 1980s. The steelhead recovery actions proposed in this plan are a natural extension of this work.

Key recovery partners include the Yakama Nation, WDFW, BOR, USFS, NOAA Fisheries, USFWS, the Washington Department of Ecology, county and municipal governments, local Conservation Districts, non-profit organizations, and other landowners and managers throughout the basin. Developing collaborative partnerships between existing organizations should take precedence over the creation of new organizations and programs unless there is a clear need for a new structure.

This plan focuses on voluntary, non-regulatory approaches to implementing recovery actions. While it does call on decision-makers to effectively implement existing regulatory programs, it does not mandate specific regulatory actions or call for new regulatory programs.

Coordinating diverse recovery efforts and ensuring that limited funding is used effectively requires ongoing collaboration between in-basin stakeholders and state and federal agencies. The Yakima Basin Fish & Wildlife Recovery Board has committed to working with recovery partners to 1) develop a regularly updated implementation schedule that prioritizes future recovery actions, 2) track completion of recovery actions, 3) promote effective use of existing funding[3], 4) work with partners to develop new sources of support for recovery actions, and 5) ensure Yakima Basin recovery efforts are coordinated with recovery efforts across the range of the Middle Columbia River Steelhead DPS.

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[3] Current funding sources include the Washington Salmon Recovery Funding Board (which distributes both federal Pacific Coast Salmon Recovery Fund dollars and state funds), the BPA/NPCC Fish and Wildlife Program, the Bureau of Reclamation's Yakima River Basin Water Enhancement Project, and the Washington Department of Ecology's Columbia River Initiative.

Research Monitoring and Evaluation

Our understanding of steelhead biology and the factors that affect steelhead habitat and survival is continually improving. Chapter 7 reviews key uncertainties and the research, monitoring, and evaluation actions that will answer them. While the extent of empirical data about Yakima Basin steelhead populations is much greater than for most other populations of the Middle Columbia River Steelhead DPS, successfully implementing this plan will require additional data collection and analyses. Targeted empirical research is needed to increase our ability to effectively and efficiently implement recovery actions. Tracking the response of steelhead to specific actions and broad habitat trends and evaluating progress towards meeting quantifiable recovery goals will require a robust monitoring and evaluation program. This research and monitoring will build on the extensive research capacity built by the Yakima/Klickitat Fisheries Program and others. Chapter 7 reviews the need for research and monitoring and identifies key uncertainties that will need to be addressed as part of implementing this recovery plan. The Yakima Basin Fish & Wildlife Recovery Board will develop a Research, Monitoring and Evaluation Plan that builds on Chapter 7 of this plan to identify critical research and monitoring needs and assess how they can be incorporated into an effective and practical adaptive management framework.

Public Education and Outreach

Chapter 8 reviews outreach and education needs and presents some initial proposals for future actions. Effectively implementing the recovery actions identified in this plan will require outreach and education activities that: 1) build support for steelhead recovery actions among decision makers, land managers, and the public at large, and 2) increase public understanding of how individual actions affect steelhead and their habitat. Outreach activities are often forgotten in the push to implement on-the-ground recovery actions, yet they are vital to sustaining the political and financial support that achieving recovery will require. The Yakima Basin Fish & Wildlife Recovery Board is committed to working with partners throughout the basin to support and expand education and outreach programs.

TABLE OF CONTENTS

1 Introduction 1

1.1 Overview of Recovery Planning 1

1.1.1 Listing of Yakima Basin Steelhead 1

1.1.2 Requirements for a Recovery Plan 3

1.1.3 Development of the Yakima Subbasin Salmon Recovery Plan 3

1.2 Vision and Guiding Principles for Local Planning 5

1.2.1 Vision 5

1.2.2 Guiding Principles 5

1.2.3 Non-Regulatory Nature of Recovery Plans 6

1.3 Process Used to Develop the Plan 7

1.3.1 Drafting of the Plan 7

1.3.2 Public Involvement 8

1.3.3 Incorporating the Local Plan into NOAA's Recovery Plan 8

1.4 Relationship to Other Recovery Activities 9

1.4.1 Relationship to Other Planning Efforts 9

1.4.2 Relationship to Ongoing On-the-Ground Recovery Efforts 10

2 Species Status 12

2.1 Regional Setting 12

2.1.1 Geographic Setting 12

2.1.2 Ecological Setting 18

2.2 Identification of Populations 19

2.3 Steelhead Distribution 20

2.3.1 Satus Population 26

2.3.2 Toppenish Population 26

2.3.3 Naches Population 27

2.3.4 Upper Yakima Population 27

2.4 Steelhead Abundance 28

2.4.1 Estimates of Historic Abundance 28

2.4.2 Current Abundance and Productivity 30

2.5 Population Characteristics and Life Histories 35

2.5.1 Adult Upstream Migration 35

2.5.2 Spawning 42

2.5.3 Role of Kelts 46

2.5.4 Incubation and Emergence 47

2.5.5 Juvenile Rearing 48

2.5.6 Resident/Anadromous Interactions 49

2.5.7 Smolt Outmigration 50

2.5.8 Ocean Residence 54

2.6 Viability Assessments for Yakima Basin Steelhead 54

2.6.1 Satus Creek 56

2.6.2 Toppenish Population 59

2.6.3 Naches Population *61*
2.6.4 Upper Yakima Population *64*
3 Factors for Decline **68**
3.1 Introduction 68
3.1.1 General Overview of Steelhead Population Decline *68*
3.1.2 Ongoing Efforts to Address the Decline of Steelhead *70*
3.2 Definition of Threats and Limiting Factors 70
3.2.1 Threats *70*
3.2.2 Limiting Factors *71*
3.2.3 Relationships of Threats to Limiting Factors *93*
3.3 In-Basin Threats and Limiting Factors 93
3.3.1 Basinwide Threats and Limiting Factors *93*
3.3.2 Lower Mainstem Threats and Limiting Factors *106*
3.3.3 Satus Population Threats and Limiting Factors *108*
3.3.4 Toppenish Population Threats and Limiting Factors *109*
3.3.5 Naches Population Threats and Limiting Factors *111*
3.3.6 Upper Yakima Population Threats and Limiting Factors *114*
3.4 Out-of-Basin Threats and Limiting Factors 117
3.4.1 Out-of-Basin Effects on the Lower Yakima Basin *118*
3.4.2 Columbia River Dams *118*
3.4.3 Columbia River Estuary *119*
3.4.4 Ocean Conditions *119*
3.4.5 Out-of-Basin Harvest *120*
3.4.6 Predation *120*
3.4.7 Competition with Non-Native Species *121*
4 Recovery Goals and Criteria **122**
4.1 Recovery Goals 122
4.1.1 Delisting Threshold *122*
4.1.2 Short-term Recovery Threshold *124*
4.1.3 Delisting & Short-term Recovery Threshold Differences *124*
4.1.4 Long-term Recovery Threshold *125*
4.1.5 Relationship of Recovery Thresholds to NOAA Delisting Decisions *125*
4.2 Recovery Objectives and Criteria 125
4.2.1 Abundance *126*
4.2.2 Productivity *127*
4.2.3 Spatial Structure *128*
4.2.4 Diversity *129*
4.3 Recovery Strategies 130
4.3.1 Habitat Strategies *130*
4.3.2 Predation Strategies *130*
4.3.3 Harvest Strategies *130*
4.3.4 Hatchery Strategies *130*
4.3.5 Recovery Strategies Outside of the Yakima Basin *131*
4.3.6 Recovery Strategies Affecting All Yakima Populations *131*

4.3.7 Role of Areas Above Storage Dams in Steelhead Recovery 131
4.3.8 Toppenish Population Recovery Strategies 132
4.3.9 Satus Population Recovery Strategies 132
4.3.10 Naches Population Recovery Strategies 134
4.3.11 Upper Yakima Population Recovery Strategies 135
5 Recovery Actions 139
5.1 Identifying and Describing Recovery Actions 139
5.2 Timeframe for Implementing of Actions 141
5.3 Necessity and Sufficiency of Proposed Actions 142
5.4 Overall Cost of Recovery 143
5.5 Recovery Action Descriptions 143
6 Plan Implementation 204
6.1 Approach to Implementation 204
6.1.1 Voluntary and Non-Regulatory Nature of Plan 204
6.1.2 Coordination of Existing Recovery Programs 205
6.1.3 Coordination with Bureau of Reclamation Yakima Project 205
6.1.4 Coordination with Land Management Agencies 206
6.1.5 Coordination with Other Planning Efforts 207
6.1.6 Coordination with Local Land Use Planning 207
6.1.7 Role of Yakima Basin Fish & Wildlife Recovery Board 207
6.2 Funding 208
6.2.1 Total Time and Cost of Recovery 208
6.2.2 Funding Sources 208
6.3 Implementation Scheduling 209
6.4 Adaptive Management 210
6.4.1 Tracking Implementation 210
6.4.2 Monitoring Habitat and Population Trends 210
6.4.3 Designing Recovery Actions to Test Key Assumptions 210
6.4.4 Revising the Recovery Plan 211
6.5 Removing Roadblocks to Implementation 211
6.5.1 Permit Streamlining 211
6.5.2 Providing ESA Assurances 211
6.5.3 Building Technical Capacity 212
6.5.4 Supporting Network of Recovery Practitioners 212
6.6 Maintaining Links to Larger Recovery Efforts 212
6.6.1 Washington State Salmon Recovery Strategy 212
6.6.2 Middle Columbia DPS-wide Coordination 213
6.6.3 Integration with Columbia River, Estuary and Ocean Recovery Efforts 213
7 Research, Monitoring and Evaluation 214
7.1 Understanding Steelhead Population Trends 215
7.1.1 Abundance and Productivity 215
7.1.2 Spatial Structure 216
7.1.3 Diversity 217

7.2 Understanding Key Factors Affecting Survival 218
7.2.1 Role of Life-Cycle Models 218
7.2.2 Separating In and Out-of-Basin Survival Rates 219
7.2.3 Impacts of Mainstem Conditions on Smolt Survival 219
7.2.4 Impacts of High Delivery Flows on Juvenile Rearing 219
7.2.5 Factors Affecting Upmigrating Adults 219
7.2.6 Resident/Anadromous Interactions 220
7.3 Understanding Habitat Trends and Threats Criteria 220
7.4 Evaluating Recovery Action Effectiveness 220
7.5 Understanding Critical Ecological Dynamics 221
7.5.1 In-Basin Predation 221
7.5.2 Interspecies Effects 222
7.5.3 Changes in Nutrient Transport 222
7.5.4 Expansion of Aquatic Vegetation 222
7.5.5 Impacts of Pesticides and other Toxins 223
7.6 Understanding Impact of Long-Term Trends 223
7.6.1 Global Warming Impacts 223
7.6.2 Future Growth Impacts 224
7.7 Coordinating Research and Monitoring Efforts 224
7.7.1 Integration with Regional Monitoring Programs 225
7.7.2 Out-of-Basin Research Needs 225
8 Public Education and Outreach 227
8.1 Introduction 227
8.2 Education and Outreach Goals and Principles 228
8.3 Proposed Outreach Actions 228
8.3.1 Short-Term Recovery Board Outreach Actions 228
8.3.2 Stakeholder Group Presentations 229
8.3.3 Newsletter/Annual Report 229
8.3.4 Project Tours 230
8.3.5 Posters and Handouts 230
8.3.6 Workshops and Conferences 230
8.3.7 Mailing to Shoreline Landowners 230
8.3.8 Create "Stream Stewards" Positions 230
APPENDIX A: Local Review of ICTRT Habitat Model 232
A.1 Overview of Review of ICTRT Intrinsic Potential Model 232
A.2 Satus Population Area 234
A.3 Toppenish Creek Steelhead Population 235
A.4 Naches Population Area 236
A.5 Upper Yakima Population Area 238
APPENDIX B: EDT Model Results for Yakima Steelhead 241
B.1 Overview of EDT Estimates of Population Performance 241
B.2 Restoration Potential and Limiting Factors by Populations 243

B.2.1 Naches River Steelhead *244*
B.2.2 Satus Creek Steelhead *246*
B.2.3 Toppenish Creek Steelhead *247*
B.2.4 Upper Yakima River Steelhead *249*
B.2.5 Integration of Restoration Priorities Across Populations *252*
B.3 Preservation Potential for Individual Populations 254
B.3.1 Naches Steelhead *254*
B.3.2 Satus Steelhead *254*
B.3.3 Toppenish Steelhead *255*
B.3.4 Upper Yakima Steelhead *255*
B.4 Use of EDT to Model Restoration Scenarios 256
APPENDIX C: RECOVERY PROGRAMS OVERVIEW 260
C.1 Introduction 260
C.2 NPCC/BPA Programs 260
C.2.1 The Yakima/Klickitat Fisheries Project *262*
C.2.2 Yakima Tributary Access and Habitat Program *262*
C.2.3 Yakima Side Channels Program *263*
C.2.4 Yakama Reservation Watersheds Project *263*
C.2.5 Manastash Creek Passage/Screening/Flow Projects *263*
C.2.6 Teanaway Watershed Protection and Enhancement *263*
C.3 U.S. Bureau of Reclamation Programs 263
C.3.1 System Operations *263*
C.3.2 Yakima River Basin Water Enhancement Project *264*
C.3.3 Yakima River Basin Water Storage Options Feasibility Study *265*
C.3.4 Storage Dam Fish Passage Feasibility Study *266*
C.4 US Forest Service Restoration Programs 266
C.5 Washington State Fish Recovery Programs 266
C.5.1 Regional Fisheries Enhancement Groups *266*
C.5.2 Salmon Recovery Funding Board Programs *267*
C.5.3 Regional Salmon Recovery Organizations *267*
C.5.4 Ahtanum Creek Watershed Restoration Program 268
C.6 Washington Department of Ecology Water Quality Programs 268
C.8 Yakima Basin Joint Board 268
C.9 Local Government Land Use Regulations 269
C.9.1 Growth Management Act *269*
C.9.2 Shoreline Management Act *269*
APPENDIX D: Stakeholder and Public Meetings 271
D.1 Stakeholder Meetings Held 2005 271
D.2 Stakeholder Meetings Held April 2006 to January 2008 272
D.3 Plan Outreach During 2008 NOAA Comment Period 273
REFERENCES 275

LIST OF TABLES

Table 2.1: Land ownership in the Yakima Basin....14
Table 2.2: Intrinsic Potential Analysis modeled habitat areas....23
Table 2.3: EDT estimates of “historic” abundance....28
Table 2.4: Historic abundance estimates derived from Intrinsic Potential Analysis....29
Table 2.5: Available dam count and redd data....32
Table 2.6: Natural-origin spawner abundance by population, 1995-2004....33
Table 2.7: ICTRT extrapolation from Prosser to population-specific abundance....34
Table 2.8: Spawner/return ratios for the brood years 1985-1999....35
Table 2.9: Timing of dam passage by adult steelheads....36
Table 2.10: Sex ratios of returning steelhead....39
Table 2.11: Prosser Denil age structures, 2002-3 to 2004-5 return years....39
Table 2.12: Roza Dam age structures, 2002-3 to 2004-5 return years....40
Table 2.13: Spawning locations of known-age steelhead by population, 1990-92....40
Table 2.14: Known spawning locations from 1990 to 1992 radio tracking....43
Table 2.15: Naches redd survey results....44
Table 2.16: Presumed spawning locations of steelhead tracked by Karp et al. (2009)....45
Table 2.17: Numbers of kelts....47
Table 2.18: Size in millimeters for outmigrating smolts at Prosser by age class....52
Table 2.19: Steelhead travel times from tributary tagging locations to Prosser Dam....53
Table 2.20: Survival rates of steelhead smolts from selected tributaries....54
Table 2.21: ICTRT risk ratings for Yakima steelhead populations....56
Table 2.22: ICTRT spatial structure & diversity ratings for the Satus population....58
Table 2.23: ICTRT spatial structure & diversity ratings for the Toppenish population....60
Table 2.24: ICTRT spatial structure & diversity ratings for the Naches population....63
Table 2.25: ICTRT spatial structure & diversity ratings for Upper Yakima population....66
Table 3.1: Basinwide threats and limiting factors....73
Table 3.2: Lower mainstem Yakima threats and limiting factors....75
Table 3.3: Satus population area threats and limiting factors....77
Table 3.4: Toppenish population area threats and limiting factors....79
Table 3.5: Naches population area threats and limiting factors....82
Table 3.6: Upper Yakima population area threats and limiting factors....86
Table 4.1: Minimum abundance criteria for recovery thresholds....126
Table 4.2: Sources for long-term recovery abundance targets....127
Table 4.3: Spawners and spawner:spawner ratio....128
Table 4.4: Possible combinations of spawning areas for the Upper Yakima....129
Table B.1 Current and historic performance generated by EDT....243
Table B.2 Restoration geographic areas for the Naches steelhead population....245
Table B.3: Restoration geographic areas for the Satus steelhead population....247
Table B.4: Restoration geographic areas for the Toppenish steelhead population....248
Table B.6: Summation of individual geographic areas across steelhead populations....253
Table B.7: Geographic preservation priorities for the Naches population....254
Table B.8: Geographic preservation priorities for the Satus Creek population....255
Table B.9: Geographic preservation priorities for the Toppenish population....255
Table B.10: Geographic preservation priorities for the Upper Yakima population....256
Table B.11: EDT Subbasin restoration summary as developed in 2005....258

Table B.12: EDT 2005 Subbasin restoration summary as adjusted in 2008 259
Table C.1: BPA-funded programs in the Yakima Basin.....261

LIST OF FIGURES

Figure 1.1: Location of Yakima MPG within Middle Columbia River DPS 2
Figure 2.1: Yakima Basin 13
Figure 2.2: Yakima Basin land ownership.....15
Figure 2.3: Irrigated areas and major storage & diversion dams.....16
Figure 2.4: ICTRT Intrinsic Potential Analysis & population areas in the Yakima.....21
Figure 2.5: Available habitat, current distribution, and blocked areas 24
Figure 2.6: ICTRT spawning areas and WDFW steelhead distribution 25
Figure 2.7: Yakima Basin steelhead abundance 31
Figure 2.8: Lower Yakima River and McNary Pool temperatures.....37
Figure 2.9: Size class by ocean age 41
Figure 2.10: Individual and median dates for spawning initiation 1990-1992 46
Figure 2.11: Steelhead smolt ages at Prosser Dam 51
Figure 2.12: Satus abundance & productivity compared to the viability curve.....57
Figure 2.13: Toppenish abundance & productivity compared to the viability curve 59
Figure 2.14: Naches abundance & productivity compared to the viability curve 62
Figure 2.15: Upper Yakima abundance & productivity compared to viability curve 65
Figure 4.1: VSP parameter risk ratings for Yakima steelhead populations.....124
Figure A.1: July 2007 ICTRT Intrinsic Potential model with local adjustments 234
Figure B.1: Example stock-production relationship 242
Figure B.2: Major reach-level limiting factors for the Naches population.....246
Figure B.3: Major reach-level limiting factors for the Satus Creek population 247
Figure B.4: Major reach-level limiting factors for the Toppenish Creek population 248
Figure B.5: Major reach-level limiting factors for the Upper Yakima population.....251

ACRONYMS

BIA	BUREAU OF INDIAN AFFAIRS
BKD	BACTERIAL KIDNEY DISEASE
BOR	UNITED STATES BUREAU OF RECLAMATION (also Reclamation)
BPA	BONNEVILLE POWER ADMINISTRATION
BW	BASINWIDE
CAG	CONSERVATION ADVISORY GROUP
CFHMP	COMPREHENSIVE FLOOD HAZARD MANAGEMENT PLAN
cfs	CUBIC FEET PER SECOND
CREP	CONSERVATION RESERVE ENHANCEMENT PRORAM
CWT	CODED WIRE TAG
DPS	DISTINCT POPULATION SEGMENT
DOE	UNITED STATES DEPARTMENT OF ENERGY
EDT	ECOSYSTEM DIAGNOSIS AND TREATMENT
EIS	ENVIRONMENTAL IMPACT STATEMENT
EPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ESU	EVOLUTIONARILY SIGNIFICANT UNIT
FTE	FULL-TIME EMPLOYEE
FPS	FISH PASSAGE CENTER
GMA	GROWTH MANAGEMENT ACT
GSRO	GOVERNOR'S SALMON RECOVERY OFFICE
ICTRT	INTERIOR COLUMBIA TECHNICAL RECOVERY TEAM
ID	IRRIGATION DISTRICT
KCT	KITTITAS CONSERVATION TRUST
KID	KENNEWICK IRRIGATION DISTRICT
LM	LOWER YAKIMA RIVER MAINSTEM
LWD	LARGE WOODY DEBRIS
MF	MIDDLE FORK
MPG	MAJOR POPULATION GROUP
MSA	MAJOR SPAWNING AREA (DEFINED BY ICTRT)
MiSA	MINOR SPAWNING AREA
N	NACHES RIVER
NF	NORTH FORK
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NMFS	NATIONAL MARINE FISHERIES SERVICE (A DIVISION OF NOAA ALSO REFERRED TO AS NOAA FISHERIES)
NPCC	NORTHWEST POWER AND CONSERVATION COUNCIL
NPPC	NORTHWEST POWER PLANNING COUNCIL (NOW NPCC, SEE ABOVE)
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
PCSRF	PACIFIC COAST SALMON RECOVERY FUND
PIT	PASSIVE INTEGRATED TRANSPONDER
RC & D	RESOURCE CONSERVATION AND DEVELOPMENT
RFEG	REGIONAL FISHERIES ENHANCEMENT GROUP
RM	RIVER MILE

RME	RESEARCH, MONITORING, AND EVALUATION
S	SATUS CREEK
SAR	SMOLT ADULT RATIO
SF	SOUTH FORK
SMA	SHORELINES MANAGEMENT ACT
SOAC	SYSTEMS OPERATIONS ADVISORY COMMITTEE (BOR YAKIMA PROJECT)
SR	STATE ROAD
SRFB	SALMON RECOVERY FUNDING BOARD
SVID	SUNNYSIDE VALLEY IRRIGATION DISTRICT
T	TOPPENISH CREEK
TLC	TOPPENISH LATERAL CANAL
TMDL	TOTAL MAXIMUM DAILY LOAD
U	UPPER YAKIMA RIVER
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
USFS	UNITED STATES FOREST SERVICE
USGS	UNITED STATES GEOLOGICAL SURVEY
USFWS	UNITED STATES FISH AND WILDLIFE SERVICE
VSP	VIABLE SALMONID POPULATION
WDFW	WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
WDNR	WASHINGTON DEPARTMENT OF NATURAL RESOURCES
WDOE	WASHINGTON DEPARTMENT OF ECOLOGY
WIP	WAPATO IRRIGATION PROJECT
WRIA	WATERSHED RESOURCE INVENTORY AREA
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
WSU	WASHINGTON STATE UNIVERSITY
YBFWRB	YAKIMA BASIN FISH & WILDLIFE RECOVERY BOARD (ALSO THE BOARD)
YFO	YAKIMA FIELD OFFICE (OF BOR)
YKFP	YAKIMA/KLICKITAT FISHERIES PROJECT
YN	YAKAMA NATION
YRBWEP	YAKIMA RIVER BASIN WATER ENHANCEMENT PROJECT
YSPB	YAKIMA SUBBASIN FISH AND WILDLIFE PLANNING BOARD
YTAHP	YAKIMA TRIBUTARY ACCESS AND HABITAT PROGRAM

1 Introduction

1.1 Overview of Recovery Planning	1.3 Process Used to Develop the Plan
1.2 Vision and Guiding Principles	1.4 Relationship to Other Recovery Activities

1.1 Overview of Recovery Planning

1.1.1 Listing of Yakima Basin Steelhead

Anadromous steelhead (*Oncorhynchus mykiss*) have declined significantly in abundance and geographic extent in the last one and a half centuries, but are still found across a broad geographic area. The National Oceanographic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) is responsible for applying the Endangered Species Act (ESA) to anadromous salmon and steelhead. NOAA Fisheries has divided habitat areas with salmon in Washington, Oregon, Idaho, and California into Evolutionarily Significant Units (ESUs), while dividing habitat areas with steelhead in those states into Distinct Population Segments (DPSs). Yakima Basin steelhead were first listed under the ESA as part of the Middle Columbia River Steelhead ESU, which NOAA Fisheries first designated as threatened on March 25, 1999 [4]. The Middle Columbia River Steelhead ESU (later DPS) included the Columbia River and its tributaries from above the Wind River in Washington and the Hood River in Oregon, upstream to, and including, the Yakima River, in Washington. Snake River basin steelhead are not included (see Figure 1.1).

In 2005-6, NOAA Fisheries revised its species determinations for West Coast steelhead under the ESA, delineating steelhead-only "distinct population segments" (DPS) in place of the earlier ESUs. NMFS listed the Middle Columbia River Steelhead DPS as threatened on January 5, 2006 [5]. The area occupied by the Middle Columbia River Steelhead DPS remained the same as the area originally designated as an ESU. The steelhead DPS does not include rainbow trout, the non-anadromous freshwater form of *Oncorhynchus mykiss*, which are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS).[6]

[4] See the Federal Register, Volume 64, p. 14517.
[5] See the Federal Register, Volume 71, p. 834.
[6] For a good overview of the history of the listing and the reasoning underlying NOAA's decision to list only the anadromous form of *O. mykiss* as a DPS, see the January 5, 2006 Federal Register notice (Volume 71, p. 834).

Figure 1.1: Location of Yakima MPG within Middle Columbia River DPS



1.1.2 Requirements for a Recovery Plan

Section 4(f) of the ESA calls for the development of recovery plans. The following are the key provisions:

- 4(f)(1) – Recovery plans shall be developed and implemented for listed species unless the Secretary "…finds that such a plan will not promote the conservation of the species."
- 4(f)(1)(A) – Priority is to be given, to the maximum extent practicable, to "…species, without regard to taxonomic classification, that are most likely to benefit from such plans, particularly those species that are, or may be, in conflict with construction or other forms of economic activity."
- 4(f)(1)(B) – Each plan must include, to the maximum extent practicable, "(i) a description of site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; (ii) objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list; and, (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal."

A recovery plan is a guidance document, or "road map" that describes the current status of a species and the actions that the federal agencies administering the ESA (NOAA Fisheries and the USFWS) have determined will lead to recovery of the listed species and its associated habitats. Recovery requires reversing the decline of a listed species and removing the threats to the long-term survival of a species that led to its listing under the ESA. When this is accomplished a species may be removed from the ESA list, or "delisted." Recovery, as defined by NOAA Fisheries, requires restoring listed species so that they become viable components of their ecosystem.[7] This document addresses the status and recovery needs of the portion of the Middle Columbia River Steelhead DPS that utilize the Yakima Basin. The Yakima Basin Fish & Wildlife Recovery Board is providing it to NOAA Fisheries in order to assist in its efforts to develop a federal recovery plan for the Middle Columbia River Steelhead DPS.

1.1.3 Development of the Yakima Subbasin Salmon Recovery Plan

This document is builds upon the Yakima Subbasin Salmon Recovery Plan, which was prepared by the Yakima Basin Fish & Wildlife Recovery Board (YBFWRB, also the Board), and its predecessor organization, the Yakima Subbasin Fish and Wildlife Planning Board (YSPB). These Boards developed this plan in response to the Washington State Salmon Recovery Act (RCW 77.85), which encourages the creation of regional recovery plans that address the needs of ESA-listed salmonid species. The

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[7] A "viable" population is defined by NOAA Fisheries as an independent population that has negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (ICTRT 2004b).

Yakima Subbasin Salmon Recovery Plan addressed the recovery needs of both of the ESA-listed fish species found in the Yakima Basin: steelhead and bull trout. The Salmon Recovery Act states that the fish and wildlife resources of the state are currently managed by state resource agencies, and that it is in the interest of the citizens of the State of Washington to retain management responsibility for these resources. Accordingly, local organizations, in cooperation with state, tribal, and federal governments, are developing recovery plans. This approach accelerates the required recovery planning process and ensures that NOAA Fisheries and USFWS consider local expertise and concerns in the preparation and approval of recovery plans.

In order to implement the Salmon Recovery Act, the Washington Salmon Recovery Funding Board and the Office of the Interagency Committee (known as the Recreation and Conservation Office) contracted with the Yakima Subbasin Fish and Wildlife Planning Board to develop a local salmon recovery plan based on guidance from the Washington Department of Fish and Wildlife (WDFW) and the Governor's Salmon Recovery Office (GSRO). The YSPB was originally convened to develop the Yakima Subbasin Plan for the Northwest Power and Conservation Council, and consisted of representatives from local governments in the Yakima Basin.[8] The YSPB worked with local partners and stakeholders to develop and review the initial draft of Yakima Subbasin Salmon Recovery Plan.

The draft plan was approved by the state and forwarded to NOAA Fisheries and the USFWS on October 26th, 2005. NOAA Fisheries subsequently reviewed the draft plan and developed a response entitled "Supplement to the Draft Yakima Subbasin Salmon Recovery Plan" (NMFS Northwest Region 2006). NOAA Fisheries announced the availability of the draft plan and the agency's supplement in the Federal Register on May 3, 2006 [9], with a formal comment period that extended until July 3, 2006.

In April 2006, in an effort to consolidate salmon recovery efforts, the Planning Board was dissolved and its duties taken on by a new organization, the Yakima Basin Fish & Wildlife Recovery Board. The new Board also took on the role of Lead Entity from the Yakima River Salmon Recovery Board, a separate Board that was also dissolved. The YBFWRB assumed responsibility for the Yakima Subbasin Salmon Recovery Plan.[10]

Since the formation of the Yakima Basin Fish & Wildlife Recovery Board, the original October 2005 draft has been revised to incorporate new information, improve clarity, and address issues identified in the NOAA Fisheries' supplement and comments received in response to publication in the Federal Register. In order to ensure clarity and facilitate incorporation into NOAA Fisheries' Middle Columbia River Steelhead Recovery Plan,

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[8] Membership in the Yakima Subbasin Planning Board included the Yakama Nation, Benton County, Yakima County, the cities of Benton, Ellensburg, Granger, Kennewick, Prosser, Richland, Roslyn, Selah, Sunnyside, West Richland, Union Gap, and Yakima, and WDFW.
[9] See the Federal Register, Volume 71, p. 26052.
[10] Membership in the Yakima Basin Fish & Wildlife Recovery Board includes the Yakama Nation, Benton, Kittitas, and Yakima counties and 18 of the 24 municipalities in the Yakima Basin. Its work is overseen by a Board of Directors and conducted through a non-profit organization that reports to the Board. For more information see http://www.ybfwrb.org.

this steelhead-specific plan was compiled from the Yakima Subbasin Salmon Recovery Plan. The Yakima Basin Fish & Wildlife Recovery Board has followed existing statutory and policy guidance to develop what we believe is an effective and practical recovery plan for steelhead in the Yakima Basin.

1.2 Vision and Guiding Principles for Local Planning

1.2.1 Vision

The recovery plan built upon the Yakima Subbasin Fish and Wildlife Planning Board's (YSPB) Vision 2020 (Yakima Subbasin Fish and Wildlife Planning Board 2005). Vision 2020 describes in general terms the desired future conditions of fish and wildlife habitats and populations in the Yakima Basin. It states:

> Yakima River basin communities have restored the Yakima River basin sufficiently to support self-sustaining and harvestable populations of indigenous fish and wildlife while enhancing the existing customs, cultures, and economies in the basin. Decisions that continuously improve the river basin ecosystem are made in an open and cooperative process that respects different points of view and varied statutory responsibilities and benefits current and future generations.

1.2.2 Guiding Principles

The Guiding Principles set the direction for the recovery plan by taking into account local economic and social conditions and concerns, generally accepted biological assumptions, treaty rights, and other applicable laws and policies. The Guiding Principles developed by the YSPB for the subbasin planning process are:

- The natural environment, including its fish and wildlife resources, is the common heritage of our diverse human community. The underlying premise of the Vision is to prepare and implement a balanced plan of action that plays a key role in the long-term sustainability of this common cultural and biological heritage in the Yakima Basin.
- The quality of water and a near natural timing and quantity of water flow (normative hydrograph) are principal indicators of a healthy river ecosystem. These indicators must be improved and monitored.
- The continued exercise of the Yakama Nation treaty-reserved and aboriginal rights to religious, subsistence, commercial, and recreational use of natural resources is recognized.
- Planning and implementation is based on voluntary actions and incentives.
- The processes of plan preparation, implementation, and amendment are open and equitable.

- The costs of plan actions are estimated in relation to benefits. Alternatives that achieve the highest benefit relative to costs are preferred. Costs of habitat and species restoration should be mitigated and distributed equitably.
- Programs and actions must be monitored and evaluated for effectiveness and may be altered as necessary.
- Balanced sustainable resource management recognizes these basic precepts:
  - The physical and biological environments are functionally interdependent relative to productivity.
  - At any level of function, productivity is finite.
  - Without actions to restore degraded functions, and to protect, avoid, and mitigate impacts to the physical and biological environment, the increasing demands of human population growth could reduce productivity to zero, with unacceptable costs to the cultures and economies of the Yakima subbasin.

The primary focus of this plan is "recovery" of listed species to levels that no longer require those species to be listed under the Endangered Species Act. However, both the mission of the Yakima Basin Fish & Wildlife Recovery Board and the specific goals identified in Chapter 4 go beyond just delisting of these species, and include maintaining population levels that support sustained harvest and diverse ecological functions. In order to reach these goals, recovery to the point where delisting is possible is a necessary first step, but not the end point. Meeting the long-term population and harvest goals of the Board will require ongoing actions even after the initial goal of delisting is met.

1.2.3 Non-Regulatory Nature of Recovery Plans

The NOAA Fisheries Recovery Plan for Middle Columbia River Steelhead and the Yakima Subbasin Salmon Recovery Plan are not regulatory documents. They lay out recommended actions, but do not require anyone to implement those actions. The intent of the plans is to provide information and guidance to those looking for ways to recover listed species. The recommendations made in the plans can only become binding commitments if decision makers subsequently incorporate them into requirements established by other governmental entities or programs according to their regular processes. The plans themselves create no obligations.

Both local and NOAA Fisheries recovery planners have repeatedly assured basin citizens and stakeholders that these recovery plans are not a regulatory mechanism, and that their implementation will not usurp or diminish the existing authority under state law or federal treaty, of any government or special district. The Board envisions that implementation of the plan will be inclusive, transparent, collaborative, cooperative, and voluntary. This approach is essential in order to build the long-term social and political support required for successful steelhead recovery. While the science, metrics and overall recovery strategy of the Yakima Subbasin Salmon Recovery Plan must guide what actions should be taken to increase steelhead productivity, there will often be additional considerations that will determine the sequence of actions that are taken, and how the actions should best be implemented so that recovery goals can be achieved in an

atmosphere of trust and cooperation. The organizations that promote implementation of these recovery plans must be flexible and innovative in using their resources so that broad understanding, support, involvement, and enthusiasm for salmon recovery is nurtured.

1.3 Process Used to Develop the Plan

1.3.1 Drafting of the Plan

In the initial 2005 draft of the Yakima Subbasin Salmon Recovery Plan, the limiting factors and actions were developed based on consideration of both bull trout and steelhead. The plan took a watershed-based approach that focused on protecting existing habitat and supporting natural habitat-forming processes. In this updated steelhead version, we have extracted the steelhead-specific information for ease of reference and incorporation into NOAA Fisheries' Middle Columbia River Steelhead Recovery Plan. We will update the bull trout section of the 2005 plan in conjunction with the USFWS's development of a bull trout recovery plan.

This plan was developed as follows:

- The Interior Columbia Technical Recovery Team (ICTRT) identified "Independent" populations for steelhead (ICTRT 2003; ICTRT 2005c). See Section 2.2 for definition of these populations.
- Current and historical conditions of each population were described, with emphasis on four general Viable Salmonid Population (VSP) parameters: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000).
- Limiting factors that led to the decline of each population in the Yakima Basin were identified. Limiting factors were identified in the Yakima Subbasin Plan based on Ecosystem Diagnosis and Treatment (EDT) model runs specific to steelhead, other watershed assessment documents and plans, the species management programs by the Yakama Nation (YN) and WDFW, NOAA Fisheries' Draft Guidelines for Limiting Factors and Threats Assessments, and recent research on habitat conditions and populations.
- Specific recovery actions were selected from those listed in the subbasin plan, and additional actions were identified consistent with "An Outline for Salmon Recovery Plans" (WDFW 2003). The plan also includes actions to respond to extinction risks consistent with the Interior Columbia Technical Recovery Team's guidelines (ICTRT 2004a; ICTRT 2004b), actions based on threats identified by stakeholders, and actions stakeholders identified for the first time during this planning process.
- The benefits, practicability, and relative cost of actions for each population were assessed.
- A suite of actions that could be implemented, were reasonable, and should provide the greatest benefit to the listed and other species was selected.

Planners believe that the proposed actions are sound. The actions identified in the plan address the range of threats to steelhead as they are understood at this time. However, outcomes are uncertain because of the lack of comprehensive knowledge about the ecological and social processes that affect fish. Unpredictable events will continue to affect recovery efforts. In order to ensure that the recovery strategy effectively incorporates improved knowledge and changing conditions, the plan calls for monitoring and evaluation efforts that assess the outcomes of recovery efforts and the response of target fish populations. Participants will take this information and updated cost estimates and use them to re-evaluate proposed actions and their priorities and update the plan.

1.3.2 Public Involvement

The public participation process for the preparation of Yakima Subbasin Salmon Recovery Plan was a continuation of the process carried out for the Yakima Subbasin Fish and Wildlife Plan. The contact list developed during the subbasin planning process was used and updated to keep interested parties informed and involved in the progression of the draft salmon recovery plan. The Yakima Subbasin Fish and Wildlife Planning Board's website remained active and updated, the media were kept informed, and there was a public comment period on each agenda of the advertised Board meetings. Board staff continued to give presentations and updates to various interested groups. During the preparation of the Salmon Recovery Plan, however, public participation activities emphasized involving stakeholders—the agencies, special districts, non-profits, economic interests, local government departments, and others that are daily engaged in consumptive use, management, or acquisition of resources that directly or indirectly affect salmon and salmon habitat. These entities include irrigation districts, conservation districts, state and federal agencies (e.g., BOR, USFS, and Washington Department of Transportation), greenways and land trusts, and local government planning and public works departments. These stakeholders funding, abilities, constraints, legal authorities, constituent interests, and internal policies will determine whether or not they can commit to the changes in their operations and programs identified in the draft Recovery Plan as necessary to restore salmon habitat.

Within the salmon recovery planning process, the interaction with stakeholders is called the Policy Forum. Board staff consulted with stakeholders during the months of March, April, and early May, beginning with a well-attended workshop held at the Yakima Convention Center on March 2, 2005. The list of Policy Forum stakeholders is shown in Appendix D. Additional outreach efforts were made throughout the planning process, as described in Appendix D, and changes were made in response to comments made during the September to December 2008 NOAA Fisheries comment period on the Middle Columbia River Steelhead Recovery Plan.

Chapter 8 of this document discusses information and outreach needs associated with recovery efforts.

1.3.3 Incorporating the Local Plan into NOAA's Recovery Plan

NOAA Fisheries is currently preparing its recovery plan for the Middle Columbia River Steelhead DPS, as mandated by the ESA. The geographic area of the DPS encompasses

much of north-central Oregon and south-central Washington. The Yakima MPG is one of four MPGs in the Middle Columbia River Steelhead DPS. It contains 20% of the acreage and four of the 18 extant steelhead populations in the DPS (see Figure 1.1). It is the intent of both NOAA Fisheries and the YBFWRB that the Yakima Subbasin Salmon Recovery Plan be the basis for the Yakima MPG portion of NOAA Fisheries' Mid-Columbia Steelhead Recovery Plan.

This excerpt includes the portion of the updated version of the Yakima Subbasin Salmon Recovery Plan that address the recovery needs of the Middle Columbia Steelhead DPS. It has been prepared specifically for reference by NOAA Fisheries in preparation of the formal federal recovery plan for Middle Columbia River Steelhead, and this excerpt is expected to be included by NOAA Fisheries as an Appendix in its final recovery plan. For the sake of brevity and clarity, this excerpt does not include those portions of the Yakima Subbasin Salmon Recovery Plan that focus solely on bull trout. Where bull trout recovery needs influence and/or overlap recovery needs for steelhead, this is noted in the excerpt.

The steelhead that spawn in the Yakima Basin spend their first years in the basins streams and rivers, and then migrate out the Columbia to the Pacific ocean before turning around and, as adult fish, migrating up the Columbia and Yakima rivers to their spawning grounds. Recovering Yakima steelhead will require taking actions that improve survival rates for steelhead in the Yakima Basin, the Columbia River, its estuary, and the ocean. The Yakima Subbasin Salmon Recovery Plan and this steelhead excerpt focus on the factors that affect steelhead during the portions of their lives spent in the Yakima Basin. The NOAA Fisheries Recovery Plan for the Middle Columbia River Steelhead DPS will combine this within-basin information with an assessment of the many factors that affect steelhead during their time outside of the Yakima Basin. These include passage through the mainstem Columbia hydropower system, conditions in the Columbia River and its estuary, harvest by both fisheries and predators, and ocean conditions. The NOAA Fisheries recovery plan will incorporate proposed actions that address these out of basin impacts.

1.4 Relationship to Other Recovery Activities

1.4.1 Relationship to Other Planning Efforts

The Yakima Subbasin Salmon Recovery Plan draws from several related planning efforts undertaken in the basin in recent years. In 2000, the Northwest Power and Conservation Council (formerly the Northwest Power Planning Council) adopted a revised Columbia River Basin Fish and Wildlife Program with the intent that the program will be more comprehensive than, but complementary to, regional, state, county, and tribal efforts. Their revised program called for an ecosystem-based approach for planning and implementing mitigation of impacts to fish and wildlife from the Columbia Basin hydroelectric system. To provide specific recommendations for the Yakima Basin, the Northwest Power and Conservation Council (NPCC) contracted with the Yakima Subbasin Fish & Wildlife Planning Board to develop the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005), which was completed in 2004 and is

the basis of much of the information contained in this recovery plan. While the Yakima Subbasin Salmon Recovery Plan focuses more narrowly on steelhead and bull trout, other resident and anadromous fish species should also benefit from the actions it identifies.

The Washington State Conservation Commission drafted a Limiting Factors Analysis of fish habitat in the Yakima Basin (Haring 2001) as part the Washington State Salmon Recovery Strategy laid out in House Bill 2496 in 1998. It provides a detailed stream-by-stream discussion of habitat conditions in the basin.

The Yakima River Basin Watershed Management Plan was developed as part of the state-wide watershed planning process under House Bill 2514. The draft plan was completed in November 2005, and addresses water supply, water quality, and fish habitat issues. Yakima, Benton, and Klickitat counties have adopted the plan, but neither Kittitas County nor the Yakima Nation have approved it. The Yakima Basin Water Resources Agency has developed a Detailed Implementation Plan for the Watershed Plan and is coordinating its implementation. It is our hope that implementation of the Yakima Subbasin Salmon Recovery Plan can be closely coordinated with efforts to implement the Watershed Plan.

1.4.2 Relationship to Ongoing On-the-Ground Recovery Efforts

WDFW and the Yakama Nation work together as co-managers to manage the basin's fish resources. These co-managers and numerous partners (including federal agencies, local governments, non-profit organizations, Conservation Districts, and local landowners and managers) have a strong history of working together to improve habitat and recovery salmon and steelhead in the Yakima Basin. Fish management programs in the basin are described in Appendix A and include fisheries enhancement projects funded by the Bonneville Power Administration's Fish & Wildlife Program, salmon restoration projects funded by the Washington Salmon Recovery Funding Board via the Lead Entity system developed by HB 2496, the Bureau of Reclamation's Yakima River Basin Water Enhancement Project, restoration projects conducted by the Wenatchee National Forest, local comprehensive and shoreline management plans and their respective regulatory programs, and numerous voluntary efforts by private individuals and organizations. The recovery strategy described in the Yakima Subbasin Salmon Recovery Plan is built on continuing and enhancing these fish restoration efforts. Meeting the recovery goals for ESA-listed fish populations within the Yakima Basin will likely require sustained efforts over the course of several decades. The estimated cost attributed to steelhead recovery for all actions identified in this plan is $269.3 million. Local budgets and economies within the basin cannot fund such expenditures on their own, and success in salmon recovery will depend on the ongoing support of state and federal governments. This support needs to be sufficient, reliable, and consistent over time.

Successfully delisting steelhead in the Yakima Basin will also require coordinating efforts with other areas within the Middle Columbia River DPS. NOAA Fisheries will only delist the Yakima steelhead Major Population Group (MPG) if delisting is deemed to be appropriate for the entire DPS. This is dependent on progress towards recovery in other MPGs in the DPS (the John Day, Walla Walla/Umatilla, and East Cascades Major Population Groups). This means that local communities in different basins that cross

local and state boundaries are dependent upon each other for success in meeting de-listing goals, and will need to work together to insure that their shared goals are met.

2 Species Status

2.1 Regional Setting	**2.4 Abundance**
2.2 Identification of Populations	**2.5 Population Characteristics & Life Histories**
2.3 Distribution	**2.6 Viability Assessments for Yakima Steelhead**

This section describes the Yakima Basin, its steelhead populations, and their population structure, distribution, abundance, characteristics, and life histories. It then reviews existing viability assessments of Yakima Basin steelhead populations. In this document, steelhead refers to the anadromous component of *O. mykiss* in the Yakima Basin, as described in Chapter 1, the Introduction.

2.1 Regional Setting

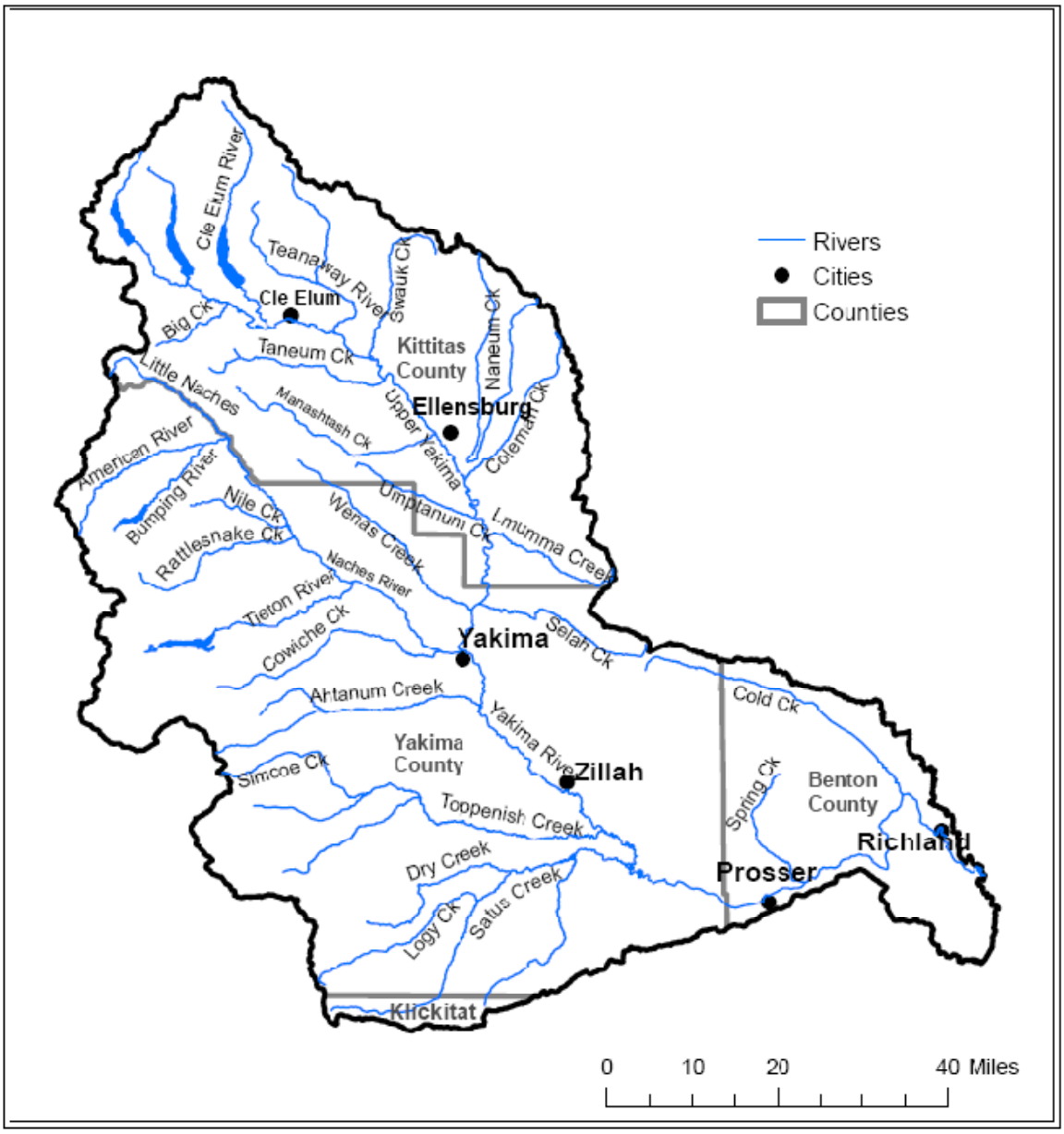
2.1.1 Geographic Setting[11]

The 214-mile Yakima River and its tributaries drain a 6,150 square mile watershed that runs from the crest of the Cascade Mountains (over 8,000 feet in elevation) to the Columbia River 333 miles upstream of the Pacific Ocean (340 feet in elevation). The Yakima River and its tributaries run through landscapes that range from the forested, mountainous terrain of the Cascades to the dry, shrub-steppe hills of the Columbia Basin. The Yakima Basin occupies two physiographic provinces (the Columbia Plateau and Cascade Mountains), and three major ecoregions, Cascades, Eastern Cascades Slopes and Foothills, and Columbia Basin (Omernik 1987). Climate, topography, precipitation, and vegetative cover are highly variable across the basin. Precipitation in the basin ranges from over 120 inches in the mountains to 7 inches in the lower Yakima Valley. Figure 2.1 shows the major rivers and streams in the Yakima Basin discussed in this recovery plan.

Basin geology dictates the form of the river valleys in the Yakima Basin. At the highest elevations of the Naches and Upper Yakima systems, streams flow through wide glacially carved valleys and glacial lakes that have been converted to serve as storage reservoirs. At lower elevations, and in other tributaries, stream channels have incised narrow canyons into the basalt and other bedrock. Valley floors near the towns of Ellensburg, Selah, Yakima, and Wapato contain deep alluvial floodplains composed of glacial outwash materials separated by geologic nickpoints consisting of bedrock outcroppings or anticlinal basalt ridges (e.g., Manastash, Umtanum, Yakima, and Ahtanum ridges). In the lower Yakima Valley, the Yakima River assumes a meandering planform atop broad floodplains composed of wind-blown soils and lacustrine silts from the Missoula Floods of the late Pleistocene (Bretz 1969).

[11] Unless otherwise noted, information for this section comes from the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005).

Figure 2.1: Yakima Basin



The longitudinal profiles of anadromous salmonid streams in the Yakima Basin respond to these physiographic and geologic factors, with stream gradients ranging from greater than 15% in the upper reaches of tributaries to the Naches River to less than 0.1% in meandering reaches of the Lower Yakima River. In many areas, the floodplains that once contained a complex network of braided channels covered by dense riparian forests have been reduced to simplified channels confined by transportation infrastructure and levees.

The basin includes parts of four counties (Kittitas, Yakima, Klickitat, and Benton) and has a population of about 300,000 people. The largest towns in the basin are Ellensburg,

Yakima, and part of two of the Tri-Cities (Richland and Kennewick). Table 2.1 and Figure 2.2 summarize land ownership in the basin.

Table 2.1: Land ownership in the Yakima Basin

OWNERSHIP	ACRES	%
Private	**1,246,818**	**31%**
Yakama Nation	**889,786**	**22%**
Federal	**1,303,297**	**33%**
Forest Service	892,509	22%
Bureau of Land Management	48,893	1%
Department of Defense	199,099	5%
Department of Energy	160,098	4%
Other Federal	2,698	0%
State	**361,403**	**9%**
Department of Fish & Wildlife	156,712	4%
Department of Natural Resources	203,085	5%
Other State	1,606	0%
Other/Unknown	**168,870**	**4%**
TOTAL	**3,970,174**	

Compiled from the Yakima Subbasin Plan (YSPB 2005)

Forests and rangelands each cover 40% of the basin. From an economic perspective, the primary land uses in the basin include irrigated agriculture (1,000 square miles or 16% of land area), commercial and residential development (60 square miles or 1% of land area), and transportation. Figure 2.3 shows irrigated acreage and major dams in the basin. Secondary land uses include recreation, forestry, floodplain gravel mining, and grazing. For a more detailed description of the Yakima Subbasin, see Chapter 1 of the Yakima Subbasin Salmon Recovery Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005). Overviews of each population area's geography are given below; population area boundaries are shown in Figure 2.4.

Figure 2.2: Yakima Basin land ownership

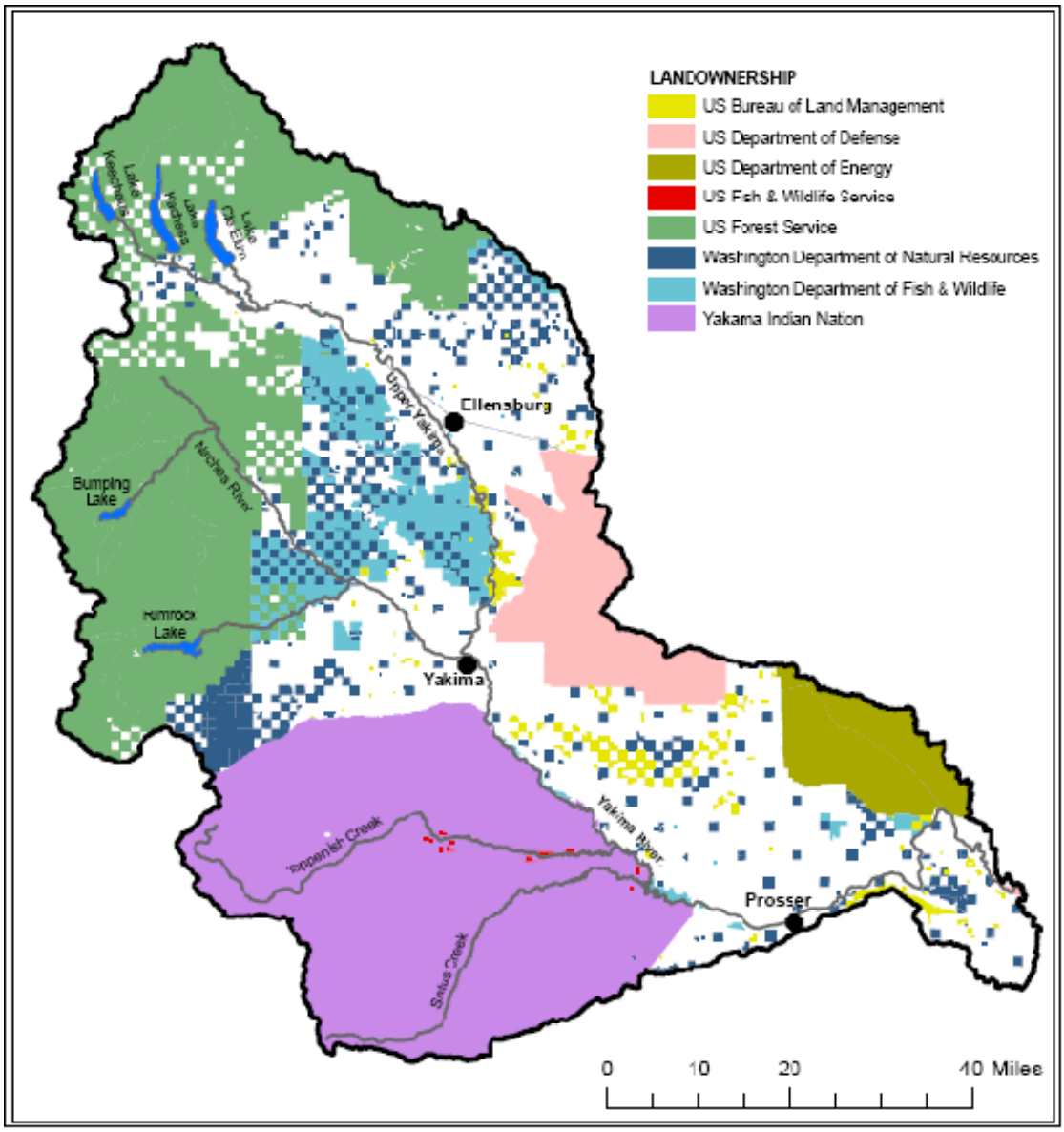
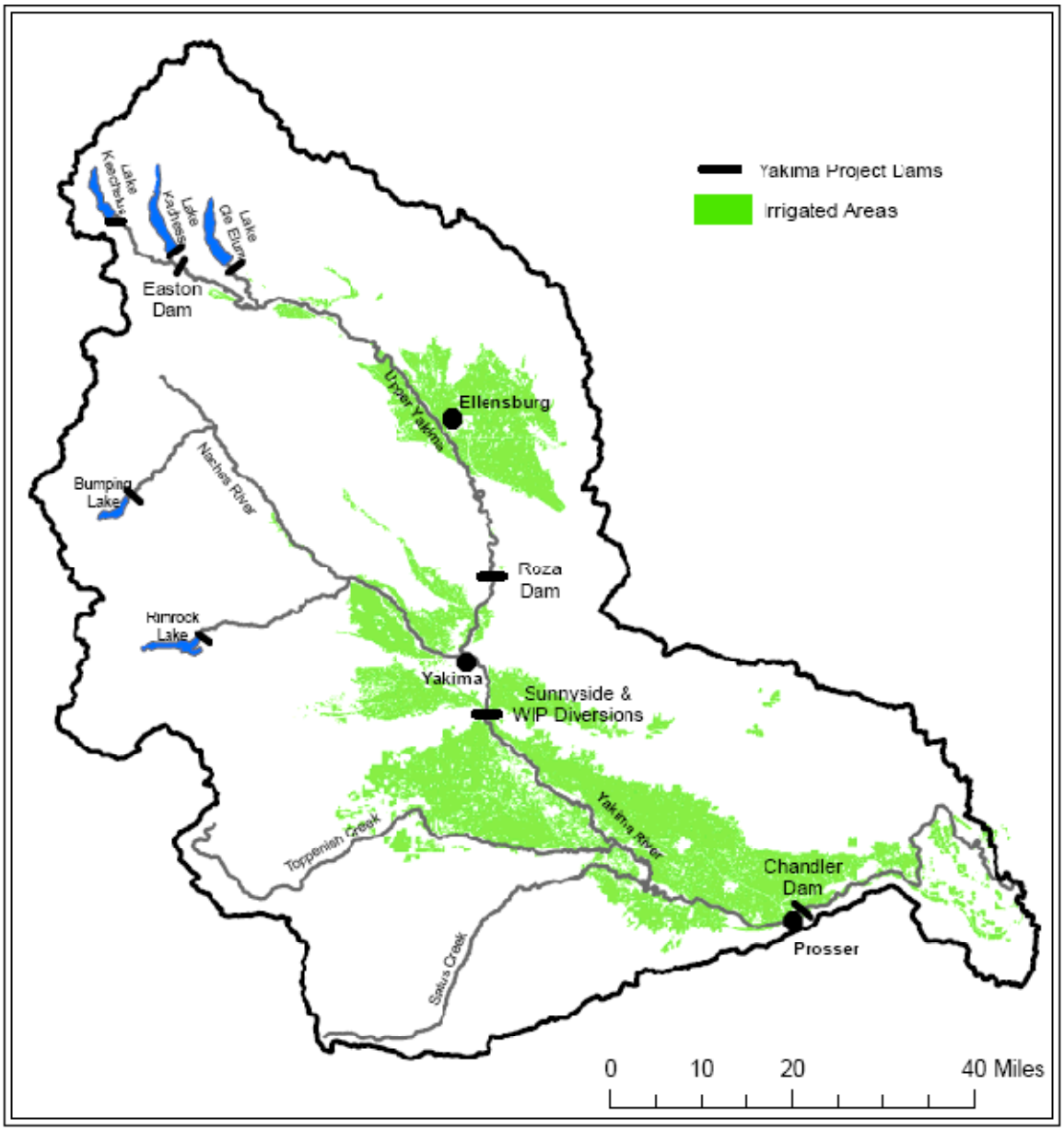


Figure 2.3: Irrigated areas and major storage & diversion dams



Satus Creek

With a drainage area of 612 square miles, Satus Creek comprises 10% of the Yakima Basin area. Many of the headwater streams in the Satus Creek watershed flow across plateaus bordered by wet meadows. As they flow generally eastward the headwater streams cascade through narrow canyons toward the relatively broad Satus Creek canyon. Satus Creek exits the canyon at RM 12.5 and flows eastward across the Yakima River floodplain to the confluence with the Yakima River. Most of the Satus Creek watershed is undeveloped and is not exposed to agricultural, industrial, or domestic effluents, but because of riparian conditions and low flow, maximum weekly average temperatures can

exceed 26^{o} C in the reach of Satus Creek between Logy Creek and Wilson Charley Creek (RM 39.3). Logy Creek cools Satus Creek for a few miles downstream from their confluence. Water quality suffers, although water quantity increases as Satus Creek flows through the Wapato Irrigation Project (WIP) in its lower eight miles. The relatively young and rapid steelhead out-migration from Satus Creek appears to be a population response to harsh historic and current summer conditions.

Toppenish Creek

The Toppenish Creek watershed, at 625 square miles, is similar in size to the Satus Creek watershed. Upper Toppenish Creek consists of three forks along with several smaller tributaries draining the Cascade foothills between Toppenish and Ahtanum ridges. These are all high gradient streams in narrow basalt canyons. Anadromous access is limited by steadily increasing gradient and coarsening substrates, not the distinct waterfalls typical in the Satus Creek system. Agency and Wahtum creeks flow into Simcoe Creek, which joins Toppenish Creek at low elevation. A few miles downstream of the Simcoe Creek confluence, the Toppenish Creek channel historically assumed a branched appearance and flowed through an extensive network of wetlands for nearly 30 miles to the Yakima River. This network has a gradient of less than 0.1%. The complexity of this network has been significantly reduced.

Naches River

The Naches River drains some of the highest and wettest terrain in the Yakima Basin. The Naches and Tieton rivers are considerably steeper and naturally more confined than the most of the Upper Yakima River. Nevertheless, the predevelopment floodplain reaches of the mainstem Naches River and its tributaries provided a labyrinth of channels surrounded by extensive riparian forests that maintained cool summer temperatures and habitat complexity for all life stages of salmon and steelhead (Kinnison and Sceva 1963; Snyder and Stanford 2001; Stanford et al. 2002). In an unregulated condition, the flow of the Naches River would be characteristic of snowmelt-dominated systems where discharge peaks between May and June concurrent with melting snow and reaches base flow in August and September. Late autumn rainfall and minor snowmelt would augment summer base flow, with occasional winter high water events under the influence of Chinook winds. Above the confluence with the highly regulated Tieton River, the Naches River and its tributaries have some of the most natural flow regimes in the Yakima Basin. Below the Tieton confluence, the Naches River floodplain widens, although a highway and other structures have isolated the river from part of the active floodplain. Rimrock Reservoir blocks passage to upstream habitat and has a major effect on flows in the Tieton River and lower Naches mainstem.

Upper Yakima River

The Yakima River above the Naches confluence is nearly 100 miles long and drains nearly twice as much area as the Naches drainage. Much of the mainstem of the Upper Yakima has relatively low gradient with extensive floodplains that once contained multiple channels and large areas of spawning and rearing habitat for salmonids, as around the towns of Easton, Cle Elum, Ellensburg, and Selah. Other reaches run through

large bedrock canyons between Cle Elum and Ellensburg and Ellensburg and Selah. The mainstem Yakima, Teanaway River, and Swauk Creek support most of the current steelhead use in the Upper Yakima population area. A number of other tributaries to the Upper Yakima River (e.g., Wilson, Naneum, Big, Little, Taneum, Manastash, Tucker, Cooke, Caribou, Coleman, and Reecer creeks) are likely to have historically supported steelhead, but impassable dams, dry reaches below dams and unscreened diversions have greatly reduced or eliminated steelhead use of these tributaries. The upper watershed contains three natural glacial lakes that now serve as storage reservoirs; historically accessible habitat above Cle Elum, Kachess, and Keechelus dams has been unavailable to steelhead since the early 20th century.

2.1.2 Ecological Setting

Steelhead use a wide range of aquatic habitats in the Yakima Basin, ranging from small intermittent streams to large multi-channel floodplains. Steelhead share the aquatic environment with at least 46 other fish species in the Yakima Basin (Fast and Berg 2001). Other species of importance include spring and fall Chinook salmon, reintroduced coho salmon, bull trout, Pacific lamprey (*Lampetra tridentata*), and westslope cutthroat trout (*O. clarki lewisi*). Sockeye are extinct in the basin, but kokanee (*O. nerka*) exist in five upper-basin storage reservoirs, and four of the populations may be descended in part from sockeye salmon present before dam construction. Summer Chinook were historically present but are now extinct in the basin. Anadromous salmon runs are thought to have once reached half a million fish or more; in recent decades combined numbers for all anadromous species have ranged from less than 3,000 in the early 1990s to more than 40,000 in 2001.[12]

Active conservation-oriented hatchery programs exist for Chinook and coho salmon. Bull trout are listed as threatened under the ESA and are under the jurisdiction of the USFWS; they are addressed in detail in the Yakima Subbasin Salmon Recovery Plan. Bull trout and steelhead distributions in the Yakima Basin currently overlap in the Naches, Ahtanum, and Upper Yakima systems. Historically bull trout would have been present across much of the current steelhead distribution, and steelhead would have been present in areas now blocked by storage dams. Currently, Pacific lamprey, and westslope cutthroat are designated as species of concern by USFWS. Steelhead recovery actions identified in this plan should benefit all these species.

There are also potential negative interactions between steelhead and other fish species. Three salmonid species (brook trout, *Salvelinus fontinalis*; lake trout *S. namaycush*; brown trout, *Salmo trutta*) have been introduced in the basin and may compete with or prey on juvenile steelhead, along with a variety of exotic sunfish, perch, catfish, and minnow species. Smallmouth bass are established in the lower river. Before the introduction of exotics, northern pikeminnow (*Ptychocheilus oregonensis*), sculpin

[12] Data compiled from Prosser Dam fish counts available online at http://www.cbr.washington.edu/dart/

(*Cottus* spp.), bull trout, rainbow trout, cutthroat trout, and burbot (*Lota lota*) were the primary piscivores in the basin.

2.2 Identification of Populations

NOAA Fisheries classified Yakima Basin steelhead as summer run steelhead within the Middle Columbia River ESU when the 1999 Endangered Species Act listing was completed.[13] Yakima Basin steelhead are the upstream-most part of the Middle Columbia River DPS. NOAA Fisheries considered including them as part of the Upper Columbia ESU but they were ultimately included in the Middle Columbia ESU due to their genetic similarity to Klickitat steelhead and the similarity of their life histories and habitat types to other Middle Columbia populations (Busby et al. 1996). Genetic analyses of Yakima Steelhead include Loxterman et al. (2003) and Phelps (2000). The ICTRT has classified Yakima Basin steelhead as one of the four Major Population Groups (MPGs) within what is now the Middle Columbia River Steelhead DPS. (The others are the East Cascades, Umatilla/Walla Walla, and John Day MPGs.) The ICTRT has further subdivided the Yakima MPG into the Satus Creek, Toppenish Creek, Naches River, and Upper Yakima River populations (ICTRT 2003; ICTRT 2005c). The population level is the basic unit used in this plan for developing recovery goals, strategies, and actions. Figure 2.4 shows the ICTRT's boundaries for the spawning areas for each of the four populations.

The Toppenish and Upper Yakima population boundaries correspond well to the informal population designations used by fish managers in the basin. The ICTRT has included the Yakima River and its tributaries from the confluence of Satus Creek to the Columbia River in the Satus Creek Population area, while fish managers in the basin generally consider the Satus Creek steelhead to include only steelhead that spawn in the Satus Creek drainage. While currently almost all the spawning in the ICTRT Satus population area occurs within the Satus drainage itself, the large extent and uncertain historic habitat value of the lower mainstem and its tributaries do affect assessments of historic potential and current viability of this ICTRT population area. Local planners have addressed this by dividing the Satus population into two parts: the Satus Creek block, which spawns within the Satus Creek watershed, and the mainstem block, which spawns in the lower mainstem and its tributaries below Satus Creek. While the Satus Creek block represents an area with known and wide spread spawning, the current and historic status of the mainstem block is uncertain. This issue is addressed in more detail in Sections 2.3.1 and 4.1.1.

The ICTRT has also included the Yakima River from Selah Gap to the mouth of Toppenish Creek and the Ahtanum Creek drainage in the Naches River population area, while fish managers in the basin have generally considered the Naches population to include only steelhead that spawn in the Naches River and its tributaries. The current and historic level of steelhead use of this portion of the mainstem Yakima is not well understood. While Ahtanum Creek steelhead may be genetically distinct from other Naches Basin populations (Small et al. 2006), the similarity in habitat and geographic

[13] See the Federal Register, Volume 64, p.14517.

proximity of Ahtanum Creek makes its inclusion as part of the ICTRT Naches population appropriate. The Naches population would still rank as a large population even if mainstem area were excluded, so no there is no separate “mainstem block.”

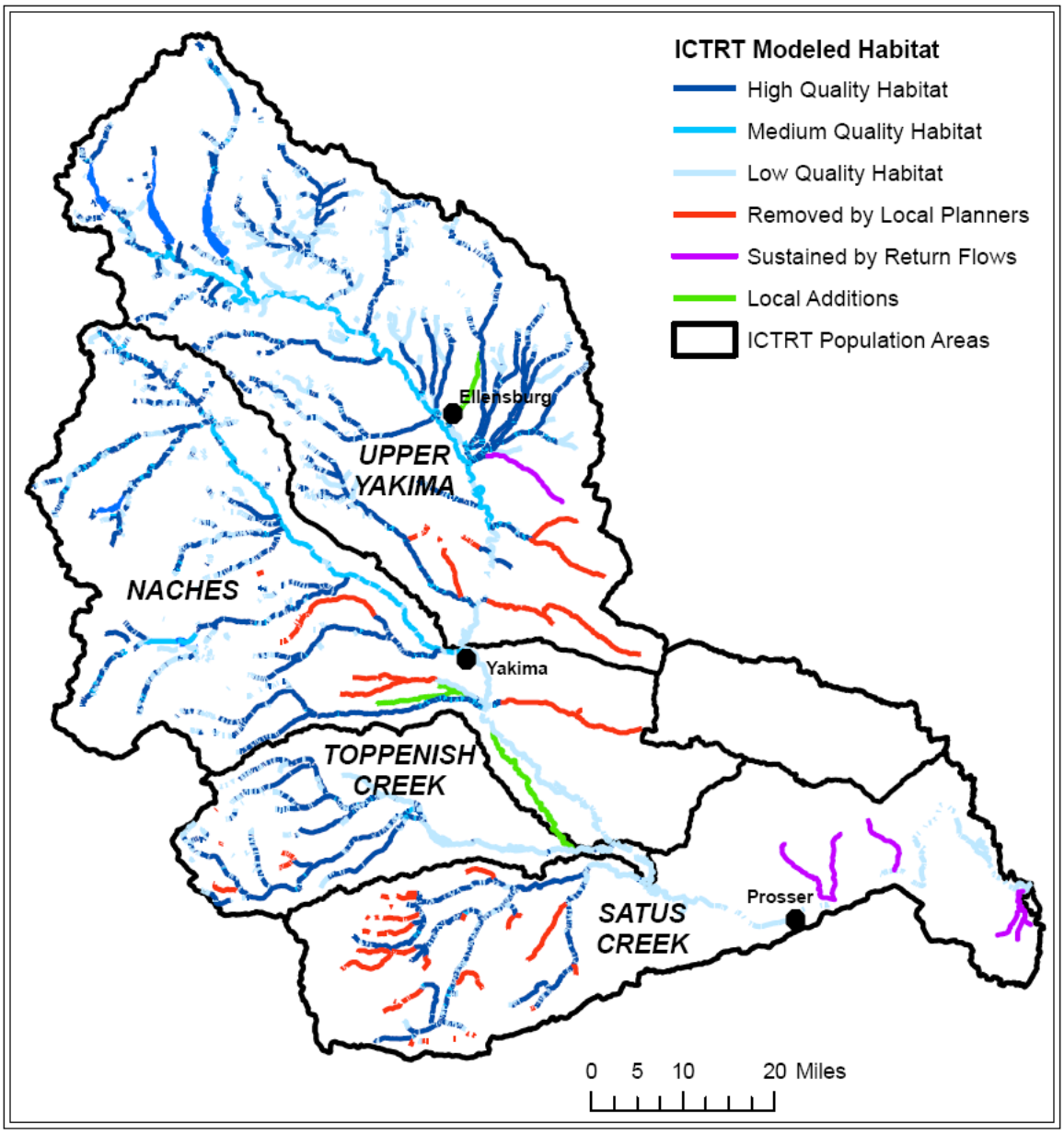
2.3 Steelhead Distribution

Steelhead are the most widespread anadromous fish in the Yakima Basin. They range from intermittent streams in semi-arid watersheds to headwaters high in the Cascades. A consensus of local managers on the current distribution of steelhead for the Yakima Basin is represented in WDFW’s SalmonScape online mapping system (included as orange symbol in Figure 2.4).[14] The USFS and the Yakama Nation maintain more detailed estimates of distribution for specific areas. The overlap between anadromous and resident forms of *O. mykiss* can make determining the exact distribution of steelhead in the Naches and Upper Yakima populations challenging. Redd surveys and radio-tracking data (Hockersmith et al. 1995; Karp et al. 2003; Karp et al. 2005) provide the most definitive information on areas used by anadromous spawners in recent years.

Numerous qualitative efforts have been made to estimate the historic and/or potential distribution of steelhead in the Yakima Basin (Haring 2001; Tuck 1995; Yakima Subbasin Fish and Wildlife Planning Board 2005). The ICTRT developed its Historic Intrinsic Potential Analysis to enable comparisons between modeled estimates of historic steelhead distribution and abundance and current steelhead distribution and abundance. These comparisons play a key role in the ICTRT’s efforts to assess the current status and potential viability thresholds for individual steelhead populations. The ICTRT has described its viability assessment procedure (ICTRT 2007b) and the Historic Intrinsic Potential Analysis (Cooney and Holzer 2006). The model estimates the amount of historically available steelhead habitat using defined decision rules and quantitative data captured in a Geographic Information System (GIS). The model focuses on identification of spawning and early rearing habitat within the Columbia Basin. It uses stream widths to calculate habitat areas in addition to simple linear stream lengths. The ICTRT model also gives a relative habitat value (high, medium, or low) to all areas identified as potential habitat, which is used to develop estimates of habitat area weighted by relative value. Model results are intended to estimate the potential habitat accessible to steelhead in the Yakima Basin using readily available measurements and consistent rules. They should not be used to classify specific areas and their current habitat values and/or potential.

[14] http://wdfw.wa.gov/mapping/salmonscape

Figure 2.4: ICTRT Intrinsic Potential Analysis & population areas in the Yakima



Local recovery planners worked closely with the ICTRT to review the results of the preliminary ICTRT Intrinsic Potential Analysis, provide additional information for inclusion into the GIS (e.g., locations of natural barriers to steelhead access), note discrepancies between results of the ICTRT analysis and previous historic/potential analyses, and propose adjustments to the decision rules that would reduce the discrepancies. To assure the integrity of their model, the ICTRT did not adjust specific model outputs to correspond with local reviews. The ICTRT adjusted the model by making changes to decision rules based on documented rationales and then applying the revised rules to the entire regional database. In general, the most current iteration of the ICTRT model takes into account these local assessments of habitat potential, but

continues to overestimate the extent of potential habitat in arid areas. Figure 2.4 shows the potential habitat identified by the model and the locations where local planners did not concur with the model results.

The model consistently assigned habitat potential to streams in semi-arid portions of the Basin that the review team identified as not generating enough flow to support steelhead. Correcting this may require refining the model's approach to predicating flow in semi-arid (under 16") precipitation regimes. The ICTRT has acknowledged this limitation and is exploring ways to build a decision rule that would better model arid watersheds. Inclusion of streams with watersheds that do not have the precipitation and/or watershed area to generate any sustained base flows was primarily an issue in the Satus Creek watershed and the lowest elevations in the Upper Yakima and Naches watersheds. These areas are marked in red in Figure 2.4. In a few cases, streams that are unlikely to have had sufficient flow to support steelhead under historic conditions now have flows that are enhanced by surface and subsurface irrigation return flows (purple on Figure 2.4) (Smith et al. 2006).

In areas with over 16" annual precipitation, model results largely matched local surveys and expert opinion. The model consistently extended lower quality habitat higher up small tributaries and headwater reaches than locally derived maps, but these differences do not make significant differences in overall population-level weighted habitat area and were considered as feasibly within historic potential by local reviewers.

The model also failed to include a few streams considered by the review team to be potential/historic habitat. In all of these cases, the streams were either distributary channels connected to other streams at both upstream and downstream ends or small spring-fed creeks in floodplains. The ICTRT has acknowledged that their model either does not recognize these streams as having sufficient watershed area to generate flow or routes flows down a single channel where channels diverged. These streams are colored green in Figure 2.4. For a more detailed description of remaining divergences between the ICTRT model and recovery planners' assessments, see Appendix A. In this plan, the locally corrected model results are used as the basis for determining potential steelhead distribution. The weighted habitat areas identified by the ICTRT model and the locally adjusted model output are listed in Table 2.2. The table shows the habitat area cited in the most recent draft of the ICTRT stock status reports; the area indicated in the updated GIS coverage of the model results provided by NOAA Fisheries; and the area remaining after local edits to the model were made. In general, the ICTRT reports include more estimated habitat area than either the updated GIS-data or the locally edited model results.

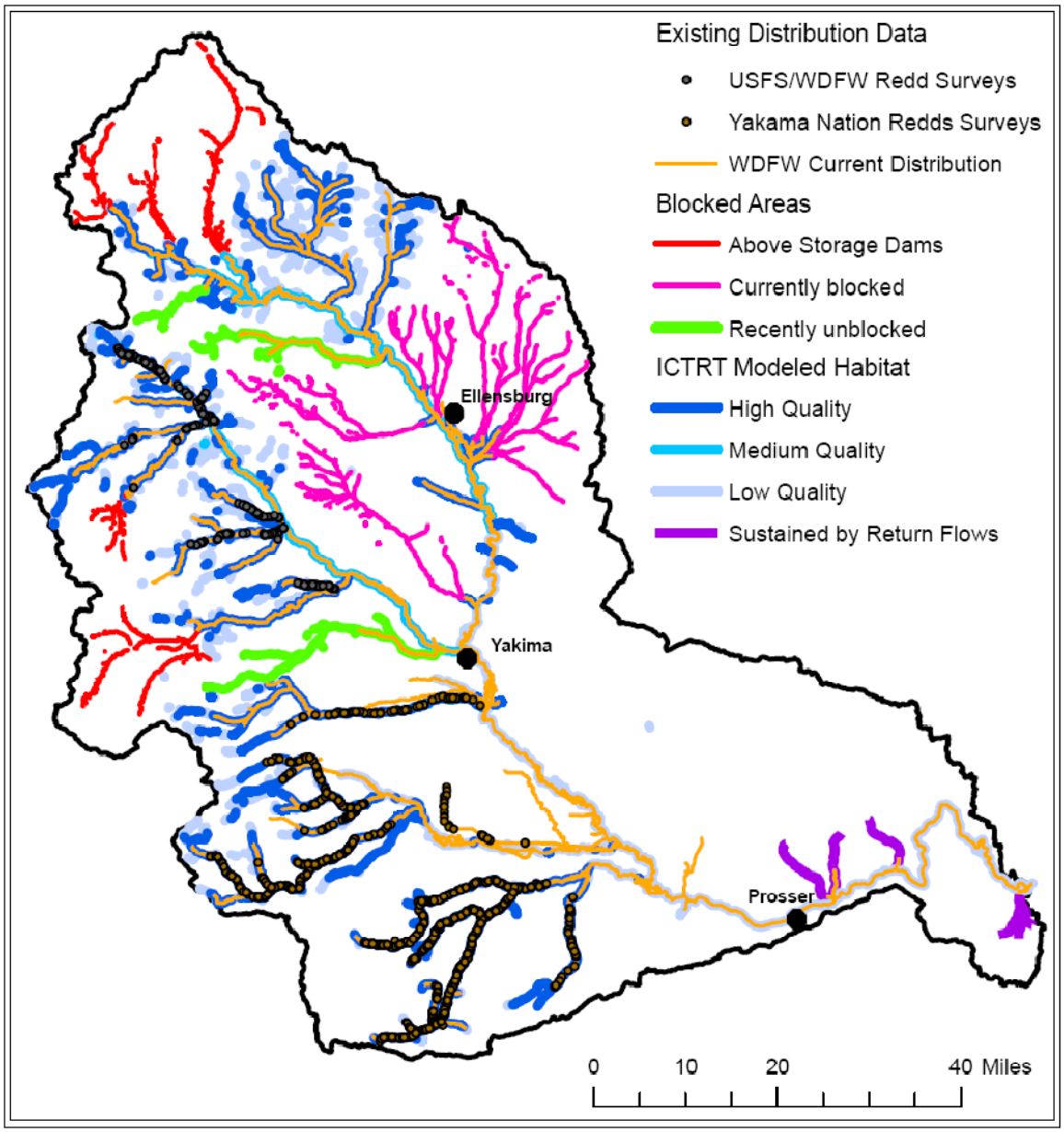
Table 2.2: Intrinsic Potential Analysis modeled habitat areas

		Total stream area weighted by intrinsic potential (m^2)	Total stream area weighted by intrinsic potential, temp limited (m^2)	Branched stream area weighted by intrinsic potential (m^2)	Branched stream area (weighted and temp. limited, m^2)
Satus					
	ICTRT Stock Status Report 7/07	4.111	1.28	1.7	0.992
	ICTRT GIS 7/07	2.981	1.053	1.447	0.802
	As Locally Adjusted	2.487	0.847	1.06	0.655
Toppenish					
	ICTRT Stock Status Report 7/07	1.909	1.171	1.17	0.803
	ICTRT GIS 7/07	1.802	1.101	1.136	0.769
	As Locally Adjusted	1.735	1.043	1.12	0.753
Naches					
	ICTRT Stock Status Report 7/07	7.207	5.849	5.088	4.495
	ICTRT GIS 7/07	7.033	5.724	5.021	4.422
	As Locally Adjusted	6.31	5.163	4.661	4.153
Upper Yakima					
	ICTRT Stock Status Report 7/07	9.038	8.795	7.531	7.456
	ICTRT GIS 7/07	8.818	8.591	7.422	7.347
	As Locally Adjusted	7.945	7.74	6.851	6.764

Figure 2.5 shows current spawning and distribution data from Yakama Nation redd surveys in the Satus, Toppenish, and Ahtanum watersheds, USFS/WDFW redd surveys in selected Naches Population tributaries, and the WDFW SalmonScape database. Redd survey data are for varying spans of years and survey intensities; they show areas where spawning is confirmed to occur but should not be used as indicators of relative spawning densities. Redd surveys have not been done in most of the mainstem Naches and Tieton

rivers[15] or in the Upper Yakima population area. Radio-tracked fish have been located in and are presumed to have spawned in all the habitat areas above Roza identified in the WDFW SalmonScape distribution (orange line) except for the Upper Yakima River above Easton Dam (Karp et al. 2003; Karp et al. 2005). Figure 2.5 also shows currently accessible habitat, blocked habitat, and recently re-opened habitat. It indicates that the locally adjusted Intrinsic Habitat Potential map of high quality habitat corresponds well with current distribution and spawning for accessible areas.

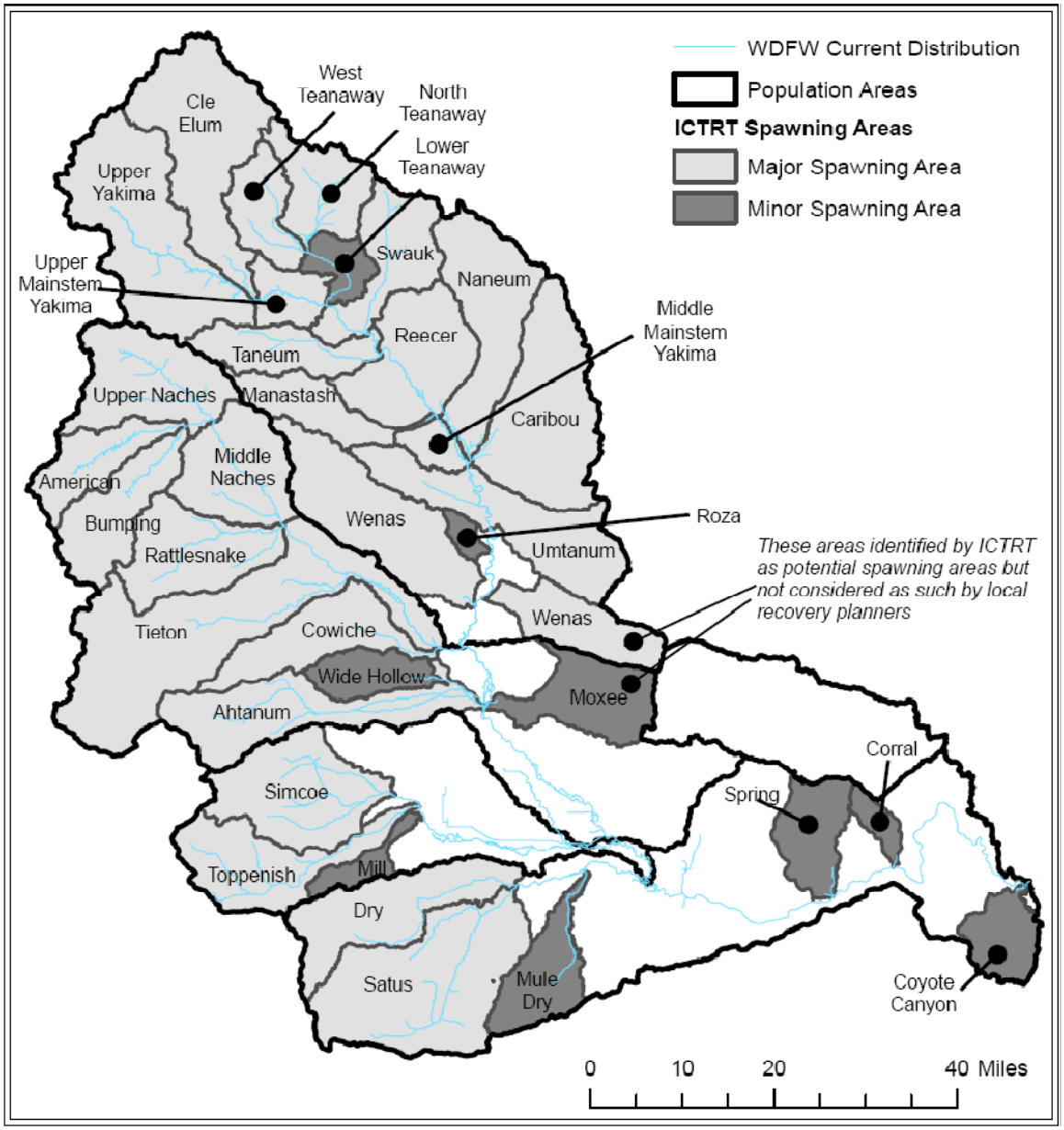
Figure 2.5: Available habitat, current distribution, and blocked areas



15 A redd survey was conducted from RM 38 to RM 27 on the Naches River by Pat Monk on 4/20/05. No redds were observed.

The ICTRT Intrinsic Potential Model (Cooney and Holzer 2006; ICTRT 2007b; ICTRT 2008) was used to designate major spawning areas (MSAs) and minor spawning areas (MiSAs) within each population area. Local recovery planners have used this as the basic unit for assessing spatial distribution in this plan. Figure 2.6 shows the ICTRT's MSAs and MiSAs overlaid with WDFW's current steelhead distribution map.

Figure 2.6: ICTRT spawning areas and WDFW steelhead distribution



2.3.1 Satus Population

The ICTRT assigned two MSAs and four MiSAs to the Satus Creek steelhead population, based on historical intrinsic potential analysis (Figure 2.6). Both MSAs and one of the MiSAs are within the Satus Creek drainage itself. The remaining three minor spawning concentrations are associated with small tributary drainages of the mainstem Yakima River.

Spawning is known to occur throughout the Satus and Dry Creek MSAs, as well as in Mule-Dry Creek MiSA. Spawning is also attributed to the Corral Creek MiSAs in WDFW's SalmonScape online mapping system. Surveys of Snipes Creek and its tributary Spring Creek have revealed small numbers of *O. mykiss* (Monk 2001) and an adult steelhead was identified 0.5 miles up Spring Creek by WDFW in 2007 (Bartand, communication, 2007). Habitat surveys in 2001 revealed that, of the left-bank drains with suitable spawning substrate, only Spring Creek had sufficient flow in the non-irrigation season to provide adult steelhead access (Romey and Cramer 2001). *O. mykiss* presence during the summer was documented in Amon Wasteway (in the Coyote Canyon MiSA) during WDFW electroshock sampling by Paul Hoffarth in 2005 and during snorkel surveys by Dr. David Smith of the University of Idaho in 2002. A planned 2007 steelhead spawning ground survey was thwarted by high flow (P. LaRiviere, WDFW, communication, 2007).[16]

For the Satus Population, the local review team was generally agreed with the ICTRT model results for the Satus Creek watershed itself, with the exception of a few tributaries indicated on Figure 2.5 that were not believed to have the flows needed to support steelhead. The habitat area within the Satus Creek drainage itself would (both with and without the tributaries in question) classify as a Basic population under the ICTRT framework, with a minimum viable abundance target of 500 returning adults. When the mainstem and tributaries to the lower mainstem were included in the Satus population, it was classified as an Intermediate population, with an abundance threshold of 1,000 spawners. The local review team felt most comfortable addressing management of these two portions of the Satus population area separately, with a threshold of 500 fish for Satus Creek watershed and another 500 for the mainstem component of the ICTRT population area; this is discussed in more detail in Section 4.3.9.

2.3.2 Toppenish Population

The ICTRT assigned two MSAs and one MiSA to the Toppenish Creek steelhead population, based on historical intrinsic potential analysis (Figure 2.6). All are within the Toppenish Creek drainage itself. Spawning is known to occur throughout the Simcoe

[16] Spring, Corral, and Snipes creeks, and Amon Wasteway are referred to by the names used on the USGS 7.5 minute topographic maps. The first three are referred to as drainageways by local irrigation districts, while Amon Wasteway is often referred to as Amon Creek. The use of these names in this document is in no way meant to indicate any conclusions regarding ongoing disputes about the legal status of these waterways.

Creek and Toppenish Creek MSAs but WDFW's SalmonScape online mapping system does not include the Mill Creek MiSA in its spawning or rearing databases. Resident *O. mykiss* were recently found in a perennial upper reach of Mill Creek (T. Resseguie, YN, communication, 2007), indicating that steelhead have used the intermittent Toppenish Creek tributary. Conversely, steelhead are shown to be present in Medicine Creek, a channel tributary to Simcoe Creek, in SalmonScape, but the ICTRT does not designate Medicine Creek as a spawning area. Medicine Creek is an abandoned distributary channel of Simcoe Creek that carried irrigation returns prior to 2003 (B. Rogers, YN, communication, 2007).

Steelhead spawning has also been documented in Marion and Harrah drains, which join near the confluence of Toppenish and Simcoe creeks. Marion Drain then flows east and enters the Yakima River 3 km upstream of Toppenish Creek (B. Rogers, YN, communication, 2007). Both drains were excavated in the 1920s to carry return flows from the Wapato Irrigation Project to the Yakima River.

2.3.3 Naches Population

The ICTRT has identified eight major historical MSAs and two MiSAs associated with the Naches River steelhead population (Figure 2.6). Seven of the MSAs are in the Naches River drainage. The remaining MSA, Ahtanum Creek, is a major tributary to the Yakima River mainstem, entering just downstream of the Naches River confluence. Impassable storage dams block the upper portions of the Tieton and Bumping watersheds. Their MSA sizes are based on modeled historic (pre-dam) habitat area. The MSA identified by the ICTRT as "Upper Naches" is actually the Little Naches River and its tributaries. The two MiSAs are small tributaries to the Yakima River between the Naches River and Ahtanum Creek. Wide Hollow Creek begins in the dry foothills west of Yakima and becomes perennial upon reaching the irrigated agricultural area surrounding Yakima. Before irrigation development, springs may have kept lower reaches of the creek perennial. Because of significant groundwater inputs, Wide Hollow Creek has received some passage and habitat funding during the past 20 years. Moxee Drain is an excavated channel draining the Roza and Selah-Moxee irrigation districts east of Yakima and receives ephemeral runoff from the arid upper Moxee Valley. Monk (2001), along with Romey and Cramer (2001), concluded that Moxee Drain was not suitable for spawning or rearing salmonids. The lower reach of Moxee drain in the Yakima River floodplain has perennial flows and provides suitable juvenile habitat. Steelhead spawning is known to occur in all eight MSAs. WDFW's SalmonScape online mapping system also includes Wide Hollow Creek and the lower end of Moxee Drain in its "documented presence" database.

2.3.4 Upper Yakima Population

The ICTRT has identified fourteen major historical MSAs and two MiSAs associated with the Upper Yakima River steelhead population (Figure 2.6). Of these, the ICTRT identifies seven as currently occupied (in both upper and lower portions) and another four

as occupied in their lower extent only (See Figure 2.6).[17] Impassable storage dams block the Cle Elum and Kachess rivers and the uppermost reach of the Yakima River. The Upper Yakima and Cle Elum MSA sizes are based on modeled historic (pre-dam) habitat area. The lower Teanaway River is designated a MiSA, probably because of the ICTRT model's branching algorithm that separated the North and West Teanaway MSAs from this lower section. The Roza Creek MiSA includes Burbank Creek which is on the other side of the Yakima River; Roza and Burbank creeks drain small, semi-arid watersheds.

2.4 Steelhead Abundance

2.4.1 Estimates of Historic Abundance

Published estimates of the size of the annual return of adult steelhead to the Yakima Basin prior to European settlement range from 20,800 (Kreeger and McNeil 1993) to "less than 50,000" (Cramer et al. 2003) to 80,000 (Howell et al. 1985) to 100,000 (Smoker 1956, as cited in WDF(1993, Appendix 3); although Cramer et al. (2003) note this is a misinterpretation of Smoker's assessment).

Table 2.3 shows estimates of "historic" abundance of anadromous spawners identified by EDT model runs conducted in development of the Yakima Subbasin Plan (see Appendix B). This estimate is based on historic conditions in the Yakima Basin coupled with current Columbia River and ocean conditions, and is not equivalent to a true historic scenario; it also does not fully address the interactions between resident and anadromous *O. mykiss* presumed to occur in the Upper Yakima and parts of the Naches basin. The population boundaries referenced here are similar, but not identical, to the updated ICTRT population designations used in this plan.

Table 2.3: EDT estimates of "historic" abundance

Population	EDT Abundance
Satus	5,761
Toppenish	4,639
Naches	14,542
Upper Yakima	21,152
TOTAL	46,094

The ICTRT used the Historic Intrinsic Potential analysis described in Section 2.4 to classify populations according to relative historic size, with Toppenish classified as a Basic population, Satus Creek as an Intermediate, and the Naches and Upper Yakima as Large populations (ICTRT In press). Table 2.4 goes a step further and uses the results of the Intrinsic Potential Analysis to extrapolate historic spawner abundance based on two calculations.

[17] See Section 4.2.3 for the ICTRT definition of "occupancy."

Table 2.4: Historic abundance estimates derived from Intrinsic Potential Analysis

		Spawner Abundance	
Population	**Locally Adjusted ICTRT Weighted & Branched Area in km2**	**at 2000/km2**	**at 0.1 smolt/m2 and 4% SAR**
Satus	1.06	2,120	4,240
Toppenish	1.120	2,240	4,480
Naches	4.661	9,322	18,644
Upper Yakima	6.851	13,702	27,404
Total	**13.692**	**27,384**	**54,768**

The first calculation is based on densities of spawning adults and multiples the estimated branched and weighted habitat area (see Figure 2.4 and Table 2.2) by an estimate of spawners per unit area. The value of 2000 spawners per km^2 is equivalent to 500 spawners per 250,000 m^2, which is the potential density of spawners used by the ICTRT to designate Major Spawning Areas based on branched habitat area (Cooney and Holzer 2006). This corresponds to 20 spawners in a hypothetical high quality stream reach 1 km long and 10m wide, or, using conversions of 1.75 spawners/redd and 1.609 km/mile, 18 redds per mile. This compares to rates of 5-10 redds per mile observed in portions of Satus Creek after an average or better steelhead run and up to 30 to 100 spawners per mile in some other areas (Rock Creek in Klickitat County at 34 to 45 redds per mile (NPPC 2004) and a range of 33 to 109 on the Middle Rogue River (ODFW 2005, p. 325). At the 2000/km^2 rate, the basin would produce about 31,000 spawners. Using 540 spawners/km^2 (which converts as above to about five redds/mile) results in approximately 8,400 fish. The second calculation is based on smolt production per unit area set at 0.1/m^2 and a smolt to adult survival rate of 4% (versus 2% generally assumed under current conditions) and results in ~62,000 spawners. Neither calculation models the impacts of resident/anadromous interactions on anadromous abundance. Note that when run with a smolt density of 0.01 smolts/m^2 and a SAR of 2% and limited to currently utilized habitat (both estimates based on empirical data from the Yakima Basin under current conditions), this simple model gives estimated abundances in line with current abundances. This admittedly simple model may serve as a useful thought tool with results that correspond with other estimates of historic abundance; its results should not be treated as definitive.

While precise estimates of historic abundance are impossible to generate, it seems reasonable to conclude that historic spawners abundances were between 25,000 and 75,000 per year. Major areas of uncertainty that affect our estimates of historic spawner abundance include:

- The extent of historic use by steelhead of the mainstem Yakima and its side channels
- The outcomes of interactions between steelhead and other salmonid species also estimated to be far more numerous under pre-European conditions, including positive relationships (enhanced supply of nutrients in headwaters) and negative relationships (increased interspecific competition)
- The nature of interaction between resident and anadromous *O. mykiss*
- The range of year-to-year variability in run size under pre-European conditions

2.4.2 Current Abundance and Productivity

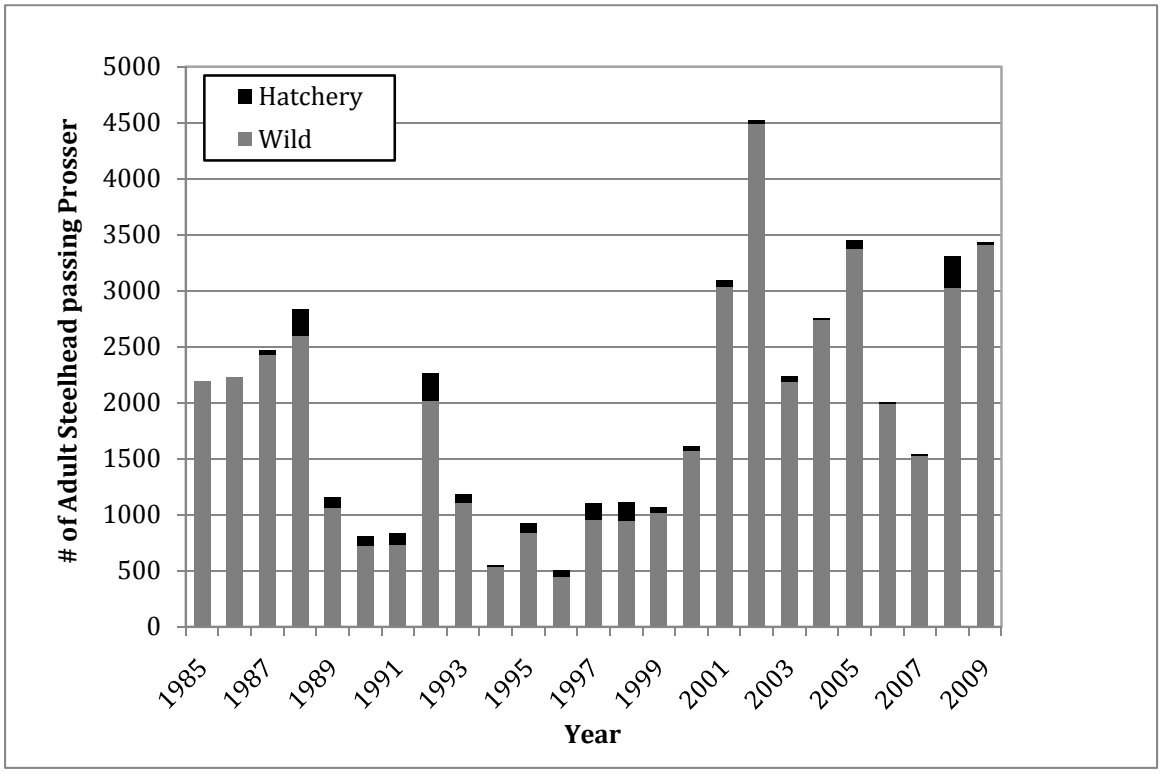
Overall Abundance in the Yakima Basin

Returning adult steelhead are counted and classified as wild or hatchery as they pass the fish ladders at Prosser Dam downstream from all major spawning areas.[18] Since records began in 1985, estimated returns have ranged from a low of 450 in 1996 to a high of 4,491 in 2002, with an average of 1,764. The run is dominated by wild fish, with a hatchery component of 8% over the period of record and 3% between 1999 and 2007.

Figure 2.7 gives an indication of the variability of recent steelhead returns. At the time of listing (1999), the 10-year average abundance for wild steelhead was 933, the majority of which was being produced in a single tributary drainage (Satus Creek). Since then abundance has increased, with the current 10-year average at 2,269. Upstream dam, redd, and smolt trap counts have also revealed a somewhat wider distribution of steelhead in the Yakima Basin than was recognized in 1999. However, even the more recent estimates of steelhead abundance are at least an order of magnitude less than even the low to middle range of estimates of historic abundance.

[18] Very limited spawning has been observed in the Yakima River and its tributaries below Prosser, but whether or not offspring survive is unknown.

Figure 2.7: Yakima Basin steelhead abundance



Abundance by Population

While the Prosser Dam counts provide excellent abundance estimates for the Yakima Basin MPG as a whole, determining the abundance of each of the four component populations is more challenging. The ICTRT's current approach apportions the total Prosser count based on a combination of 1990-92 radio-tracking data (Hockersmith et al. 1995), redd counts from Satus and Toppenish creeks and counts at the Roza Dam fish ladder. Table 2.5 summarizes available data from Yakima/Klickitat Fisheries Project dam counts, Yakama Nation Fisheries redd counts for Satus, Toppenish, and Ahtanum watersheds, and USFS/WDFW led redd counts for selected Naches tributaries.

Table 2.5: Available dam count and redd data

	Ladder Counts (July 1 to June 30)				Redd Counts			
Year Ending	**Prosser Wild**	**Prosser Hatchery**	**Roza Wild**	**Roza Hatchery**	**Satus**	**Toppenish**	**Ahtanum**	**Naches Tribs**
1985	2191	0	6	0	*	*	*	*
1986	2230	0	3	0	*	*	*	*
1987	2424	41	0	0	*	*	*	*
1988	2601	239	0	0	445	*	*	*
1989	1066	96	0	0	404	45	*	*
1990	727	87	0	0	289	26	*	*
1991	730	104	0	0	125	* (32)	*	*
1992	2012	251	107	9	*(121)	*(38)	*	*
1993	1104	80	15	0	73**(118)	*(43)	*	*
1994	540	14	28	0	114	*(49)	*	*
1995	838	87	22	1	85***(131)	*(55)	*	*
1996	450	54	90	2	148	*(61)	*	*
1997	961	145	22	0	76	5**(66)	*	*
1998	948	165	51	0	190	13**(71)	*	*
1999	1018	52	14	0	130	78	*	*
2000	1571	40	14	0	169	185	11	*
2001	3032	57	133	7	252	355	8	*
2002	4491	34	236	2	298	111***(291)	13***	*
2003	2190	45	128	6	319	161***(227)	16***	*
2004	2739	15	211	2	117	56***(163)	12***	94**
2005	3377	74	224	3	110	99	14	140
2006	1995	10	121	2	60	21***	1***	19**
2007	1523	14	60	0	87	44***	4***	44**
2008	3025	285	171	5	110	68***	8***	11**
2009	3412	24	204	0	119	79***	3***	29**

* No survey; ** Partial survey; *** Survey affected by poor redd visibility; (#) Interpolation used by ICTRT
Dam count data from www.ykfp.org; redd data from Yakama Nation staff except for USFS data for Naches data from USFS.

Given that we do not have direct counts for all populations, the best existing population-specific abundance estimates are from the ICTRT stock status reviews (ICTRT In press) and are summarized in Table 2.6; Table 2.7 shows how Prosser counts were apportioned to derive these estimates. The ICTRT adjusted aggregate annual Prosser counts to account for estimated losses between Prosser Dam and tributary spawning by applying 11% average loss rates from the 1990 to 1991 radio-tracking studies (losses directly associated with tagging were excluded). Prior to 1995, an additional 2% of the returns passing Prosser were attributed to harvest (directed harvest was closed after 1994). Population-specific abundance estimates for return years 1985-1989 were generated by applying the average distribution from the 1990 to 1992 radio tagging studies to the Prosser Dam count adjusted for pre-spawning mortality (Table 2.13). For those return years where radio tag-based distribution estimates were available (1990-92), the aggregate count over Prosser Dam was allocated among populations based on the relative distribution of radio tagged steelhead during the spring spawning time window.

For each of the return years, 1993-2004, an estimate of the aggregate number of spawners in Satus and Toppenish creeks was generated by subtracting the Roza Dam count and the

Naches River abundance estimates from the Prosser count adjusted for prespawning losses. The resulting composite estimate was allocated to Satus Creek and Toppenish Creek based on the annual ratios of expanded redd counts for the two populations. Redd counts provide the only current index to adult abundance, and redd counting conditions are more favorable in these two watersheds than in the upper basin. Redd counts in the Naches River and its higher-elevation tributaries are not a reliable index of spawner abundance, and the lower Naches River lacks an impassable dam and counting facility similar to Roza Dam in the Yakima River above the Naches confluence. This leaves managers with 15-year-old radio-tracking data for allocating Prosser adults, after subtracting upper Yakima River returns, to the Naches River and a Satus-Toppenish composite. Genetic sampling of adults at Prosser and/or new radio-tracking studies would greatly improve population specific abundance and productivity estimates.

For run years 1993-2004, Roza Dam counts were incorporated into abundance estimates for the Upper Yakima population. During the Hockersmith study, some radio tagged steelhead were tracked to the mainstem Yakima River below Roza Dam but above the confluence with the Naches River. To account for possible spawning below Roza Dam, the year-specific counts at Roza Dam were averaged with corresponding estimates based on the 1990-92 radio telemetry proportion returning to the Upper Yakima.

Hatchery releases of steelhead into the Yakima system ceased after 1993 (Fast and Berg 2001); the proportion of returning spawners at Prosser Dam that are of natural origin has averaged 94% since 1985 (99% for the most recent five years). The ICTRT assumed that hatchery strays were not disproportionately present in any specific populations.

Table 2.6: Natural-origin spawner abundance by population, 1995-2004

Population	Low (year)	High (year)	1995 to 2004 Geomean
Satus	138 (1998)	1,000 (2002)	379
Toppenish	44 (1990)	1,252 (2002)	322
Naches	142 (1996)	1,454 (2002)	472
Upper Yakima	34 (1994)	283 (2002)	85

Table 2.7: ICTRT extrapolation from Prosser to population-specific abundance

				Satus		Toppenish		Naches		Upper Yakima	
Year	Prosser #	Mortality	Spawners	% total	#	% total	#	% total	#	% total	#
1985	2191	13%	1901	45%	849	12%	222	36%	691	7%	139
1986	2230	13%	1935	45%	864	12%	226	36%	703	7%	142
1987	2465	13%	2138	45%	955	12%	249	36%	777	7%	157
1988	2840	13%	2464	45%	1101	12%	287	36%	895	7%	181
1989	1162	13%	1008	45%	450	12%	118	36%	366	7%	74
1990	814	13%	706	43%	304	7%	49	43%	304	7%	49
1991	834	13%	723	37%	268	13%	94	40%	289	10%	72
1992	2263	13%	1963	54%	1060	15%	294	26%	510	5%	107
1993	1184	13%	1027	43%	446	16%	163	36%	373	4%	45
1994	554	11%	493	40%	197	17%	85	36%	179	7%	32
1995	925	11%	824	41%	340	17%	143	36%	299	5%	42
1996	504	11%	449	35%	158	15%	65	36%	163	14%	62
1997	1106	11%	985	32%	310	27%	270	36%	358	5%	47
1998	1113	11%	991	42%	413	16%	156	36%	360	6%	62
1999	1070	11%	953	37%	353	22%	212	36%	346	4%	42
2000	1611	11%	1435	28%	408	31%	446	36%	521	4%	60
2001	3089	11%	2753	13%	353	45%	1229	36%	1000	6%	171
2002	4525	11%	4032	26%	1040	31%	1261	36%	1465	7%	267
2003	2235	11%	1991	33%	659	24%	469	36%	723	7%	140
2004	2755	11%	2455	20%	496	35%	870	36%	892	8%	197
1995-2004 geomean all spawners			*1389*		*405*		*344*		*505*		*87*

Prosser # = Prosser wild plus Prosser Hatchery from Table 2.5
Presumed 11% mortality from Prosser to spawning from Hockersmith plus 2% in-basin harvest prior to 1994
1990 to 1992 run approtionment done using Hockersmith data for those years;
1985 to 1989 done using average run portion data from the Hockersmith study;
1993 on:
Hockersmith average used for Naches (36%)
Avg of Hockersmith average & annual proportion of Roza to Prosser count used for Upper Yakima;
Remainder of Prosser count attributed to Satus and Toppenish; divided between the two based on the relative redd numbers (gaps in redd data interpolated linearly)

Productivity by Population

The ICTRT used the adult age structure from the 1990-92 radio tagging study to calculate returns per spawner. To estimate intrinsic productivity (the rate at which the population rebuilds when depressed to low numbers), the ICTRT calculated geometric means of spawner/return ratios for those data pairs where parent spawner abundance was less than 75% of the abundance target for the population. This approach is designed to minimize density dependant effects that may influence the average productivity value. The ICTRT then applied a further adjustment to compensate for annual basinwide fluctuations in marine survival. Table 2.8 shows the results.

Table 2.8: Spawner/return ratios for the brood years 1985-1999

Population	Low (year)	High (year)	15-yr Adjusted*
Satus	0.19 (1992)	2.36 (1996)	1.40
Toppenish	0.30 (1985)	14.48 (1996)	1.60
Naches	0.37 (1986)	5.03 (1996)	1.12
Upper Yakima	0.35 (1988)	4.87 (1997)	1.12

*Median delimited and adjusted based on marine survival, as per text and ICTRT (2007b)

2.5 Population Characteristics and Life Histories

2.5.1 Adult Upstream Migration

Timing of Upstream Migration

All Yakima Basin steelhead are classified as summer steelhead based on the timing of their return from the ocean to the Columbia River. Table 2.9 shows the seasonal progression of upstream migrants from Bonneville into the Yakima. Adult steelhead that were tagged with passive integrated transponders (PIT tags) in Satus, Toppenish, and Ahtanum creeks as juveniles have migrated upstream past Bonneville Dam from May through October, with 90% passing Bonneville in July (62%) and August (28%). About a third of the run then moves relatively rapidly up the Columbia past McNary in July (19%) and Aug (9%). The majority of the run holds in the Columbia between Bonneville and McNary into the fall, with Yakima steelhead presumably forming part of the large concentrations of steelhead found holding in the cool waters at the mouths of tributaries such as the White Salmon and Klickitat rivers. In September and October, 64% of the run continues past McNary, while in November and December the last 8% passes. Timing of movements through the Columbia may differ for steelhead from other parts of the Yakima Basin. Assessing this requires additional PIT-tag data from the Naches and Upper Yakima populations.

Table 2.9: Timing of dam passage by adult steelheads

	Bonneville	McNary	Prosser	Roza
	n=58	n=47	n=19332	n=1088
June	3%	0%	0%	0%
July	62%	19%	0%	0%
August	28%	9%	0%	0%
September	3%	38%	12%	2%
Oct	2%	26%	32%	3%
Nov	0%	2%	19%	1%
Dec	0%	6%	8%	0%
January	0%	0%	10%	2%
February	0%	0%	7%	4%
March	0%	0%	6%	34%
April	0%	0%	4%	49%
May	2%	0%	1%	5%
Bonneville & McNary data from PIT-tagged adults tagged as juveniles in Satus, Toppenish, and Ahtanum creeks, 2004 to 2006				
Prosser and Roza data from dam counts of adults, 2000 to 2006				

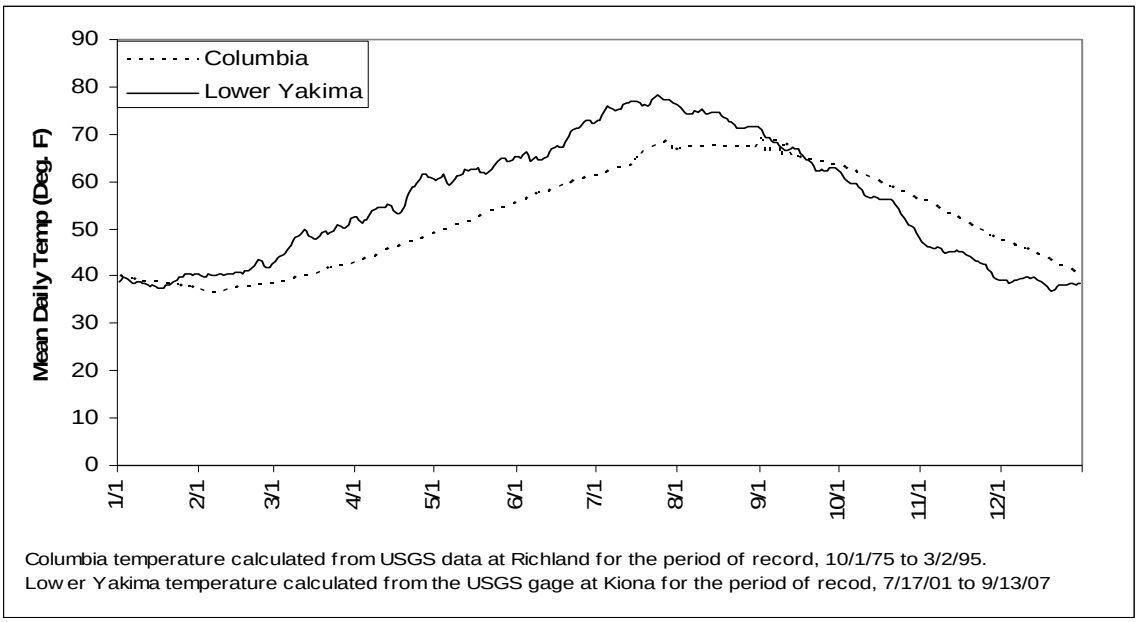
Most (63% of dam counts from 2000 to 2006) of the run continues from McNary relatively rapidly past Prosser in September, October and November. However about one third of the run holds between McNary and Prosser until December through April before passing Prosser. These fish may be using habitat in both the McNary Pool of the Columbia (where temperatures are lower through the summer) and the lower Yakima River, which cools off faster than the McNary Pool after September 1 (Figure 2.8). Where and how fish use the McNary Pool and the Lower Yakima and how that is affected by habitat conditions is noted as a key knowledge gap in Chapter 7.

While limited numbers of PIT tags make any conclusions preliminary, existing data suggest that a significant percentage of Yakima-origin steelhead overshoot the mouth of the Yakima and continue up the Columbia, with some ascending as many as four more dams on the Columbia before turning downstream to return to the Yakima. The main source of evidence is from adult steelhead tagged in the trap at Priest Rapids dam. Of the 3,890 adult steelhead tagged there between 7/12/06 and 10/16/08, 72 were subsequently detected at Prosser, with no returns from Prosser to the Upper Columbia noted so far. Of the 72 tagged steelhead, 2 were also detected at Ice Harbor after release from Priest Rapids: 1 before detection at Prosser and 1 after detection at Prosser. There were 6 Priest Rapids-tagged adults that reached Wells Dam before falling back and ascending Prosser Dam. One of them later ascended Roza Dam.

Returns of adult steelhead PIT tagged as juveniles in the Yakima Basin also indicate some Yakima steelhead pass the Yakima to ascend farther up the Columbia. Fifty-one adult steelhead tagged as juveniles in the 2006-07 outmigration and earlier were detected ascending Prosser ladders from 5/28/05 through the 2008-9 adult migration. The nine adults that were tagged as juveniles in the Yakima Basin during the 2006-07 outmigration

have been detected as adults at Priest Rapids Dam as of October 2008. Of these nine Priest Rapids detections of Yakima steelhead, four returned to Prosser. The need to better understand the rates of overshot by returning adults, its causes, and the implications for survival and condition of returning spawners is highlighted as a key uncertainty in Section 7.2.5.

Figure 2.8: Lower Yakima River and McNary Pool temperatures



While at least some adult steelhead movement into the Yakima Basin and past Prosser Dam has been documented in every month of the year, the main migration past Prosser Dam occurs from September through April. Passage from the McNary Pool and/or Lower Yakima River past Prosser Dam appears to be driven by flow and temperature cues, with fish generally moving rapidly following increased flow and moderating water temperatures.

In the two years between 1999 and 2007 when spring high flows (>2000 cfs) and lower river temperatures (< 68 ºF at Kiona) continued into July, a portion of the run passed Prosser in July (28 in 1999 and 10 in 2002). In the only other year (2004) where mean daily temperatures in July were below 68ºF at Kiona, flows remained lower (<1000 cfs) and no steelhead passed Prosser.[19] Prior to regulation of flows in the Yakima and Columbia rivers, the high flows and lower temperatures of spring runoff would have prevailed longer into the summer. It is likely that historically, some portion of the steelhead run would have traveled rapidly from the ocean into the Yakima system during the summer, but that high temperatures in the Columbia and lower Yakima rivers now limit that run timing.

[19] Analyses based on passage data accessed via DART http://www.cbr.washington.edu/dart/dart.html; Prosser flow and temperature data at http://www.usbr.gov/pn/hydromet/yakima/yakwebarcread.html.

In those years when more than two steelhead passed Prosser in August (2000, 2003, 2004 and 2007), there appears to be a significant correlation between fish movements and periods when flows increase and temperatures drop below 70ºF. The typical September beginning of the upstream run past Prosser occurs when river temperatures at Kiona consistently drop below 70ºF (in 2001, when low flows and high temperatures persisted through most of September, steelhead movement past Prosser began in late September). Throughout the fall and winter run, fish tend to move in response to increased flows, though low water temperatures can limit the influence of a midwinter flow increase, and a midwinter rise in temperature can stimulate movement even when flow remains relatively constant.

Most steelhead that pass Prosser in the fall overwinter in the Yakima River between Prosser and Sunnyside dams in reaches with deep pools and low velocity (Hockersmith et al. 1995). The final migration from holding areas to the spawning grounds begins between January and May, with fish that will spawn in lower elevation tributaries generally beginning to move earlier. Eighty-eight % of steelhead passage past Roza into the Upper Yakima occurs in March, April and May with the remaining 12% scattered from September through February. Radio tracking in 2002 through 2004 found that upstream movements above Roza towards spawning areas peaked in mid-March, but could occur anytime between November and late June (Karp et al. 2003; Karp et al. 2005).

Currently the range of run timings for specific populations cannot be accurately determined; all information presented here (except for Roza passage) is for the Yakima MPG as a whole. Developing the ability to identify steelhead to population at Prosser and increasing the number of PIT tags for the Naches and Upper Yakima populations would facilitate determining if there are significant differences in run timing between the four populations.

Age and Sex Distribution of Upstream Migrants

From 2000 to 2006, an average of 75% of the returning adult steelhead handled at the Prosser Denil and Roza Trap were females, as shown in Table 2.10 over the three years of the Hockersmith study (1990-92), radio-tagged fish were 73%, 78%, and 64% female (Hockersmith et al. 1995). Currently the only population-specific sex ratio that can be determined is for the Upper Yakima Population, which is slightly higher than the aggregate rate. With improvements to our ability to assign fish to population at Prosser, we will be able to determine if sex ratios are similar across all four populations and their subpopulations, or if they differ (perhaps based on degree of overlap with resident fish).

Table 2.10: Sex ratios of returning steelhead

		Prosser				Roza	
	Total	Female	%		Total	Female	%
2001-2	472	329	70%		210	153	73%
2002-3	169	143	85%		126	110	87%
2003-4	575	389	68%		207	154	74%
2004-5	985	629	64%		201	167	83%
Totals	2201	1490	68%		744	584	78%

Yakima Basin steelhead cover a wide range of combinations of freshwater and ocean ages with residence in freshwater ages ranging from one to four years followed by one to three years of saltwater residence (the saltwater age does not include the winter spent by adults in freshwater prior to spawning).

Table 2.11 shows the combinations of fresh and saltwater ages determined through scale analysis of steelhead handled in the Prosser Denil for the 2002-3 to 2004-5 return years (this sample is representative of steelhead passing Prosser in September to December, but does not include fish passing after December).[20] The bulk of the run consists of age 2.1 and 2.2 fish (with a combined total of between 63% and 80% all years). The age structure of the run can vary significantly from year to year, as indicated by the range separating minimum and maximum percentages for each age class. On average, males return at younger freshwater and ocean ages (1.1 fish make up 15% of males, versus 8% of females, and for fish of freshwater age two, males return proportionally more often as one ocean fish). Based on summary tables in Hockersmith et al. (1995), there is also a weak inverse correlation between freshwater age and saltwater age for the sample as a whole (i.e., younger smolts returned at slightly older average ocean age).

Table 2.11: Prosser Denil age structures, 2002-3 to 2004-5 return years

Ages from scale analysis; n = 1729

Age	Min %	Max %	Total %	% Males	% Females
1.1	1.2%	25.5%	9.4%	14.6%	7.8%
1.2	0.5%	11.2%	4.4%	3.7%	5.0%
2.1	36.7%	77.0%	53.3%	64.0%	51.9%
2.2	3.1%	28.4%	16.8%	8.7%	21.2%
2.3	0.0%	0.2%	0.1%	0.2%	0.1%
3.1	1.2%	15.5%	7.5%	7.5%	7.9%
3.2	0.2%	3.0%	1.5%	0.4%	2.1%
4.1	0.0%	1.2%	0.5%	0.1%	0.6%
Rs	2.3%	17.2%	6.5%	0.8%	3.4%

[20] Ages are given as (# of freshwater winters) and (# of saltwater winters), so a 2.3 age fish would have had two winters in freshwater as a juvenile followed by three winters at sea. Rs = repeat spawner.

Age distribution appeared to differ somewhat among populations. Table 2.12 shows the age distribution of the steelhead sampled at Roza Dam, which comprise most of the Upper Yakima population for the 2002-3 to 2004-5 returns. When compared to the aggregate run at Prosser, Upper Yakima fish are weighted towards older fish freshwater and ocean ages: one freshwater fish represent 4% of returns vs. 14% for the aggregate sample, while two ocean fish represent 52% of the Roza return vs. only 23% at Prosser.

Table 2.12: Roza Dam age structures, 2002-3 to 2004-5 return years

Ages from scale analysis; n = 534

Age	Min %	Max %	Total %	% of males	% of females
1.1	0.0%	3.3%	1.1%	2.3%	0.8%
1.2	0.5%	5.6%	3.2%	1.2%	3.7%
2.1	5.6%	69.6%	34.4%	58.3%	28.2%
2.2	3.9%	72.6%	42.2%	33.7%	44.4%
2.3	0.0%	0.0%	0.0%	0.0%	0.0%
3.1	0.5%	19.3%	7.5%	2.3%	8.9%
3.2	1.0%	11.0%	7.0%	0.6%	8.6%
4.1	0.0%	0.5%	0.1%	0.0%	0.1%
4.2	0.0%	0.8%	0.3%	0.0%	0.4%
Rs	2.0%	7.1%	4.2%	1.6%	4.9%

In contrast, data on the 70 of the 99 known-age adults that were tracked to spawning locations in the Hockersmith (1995) radio-tracking study (Table 2.13) found that known-age Satus spawners had younger freshwater ages than the other three groups and younger saltwater ages than the Naches and Toppenish groups.

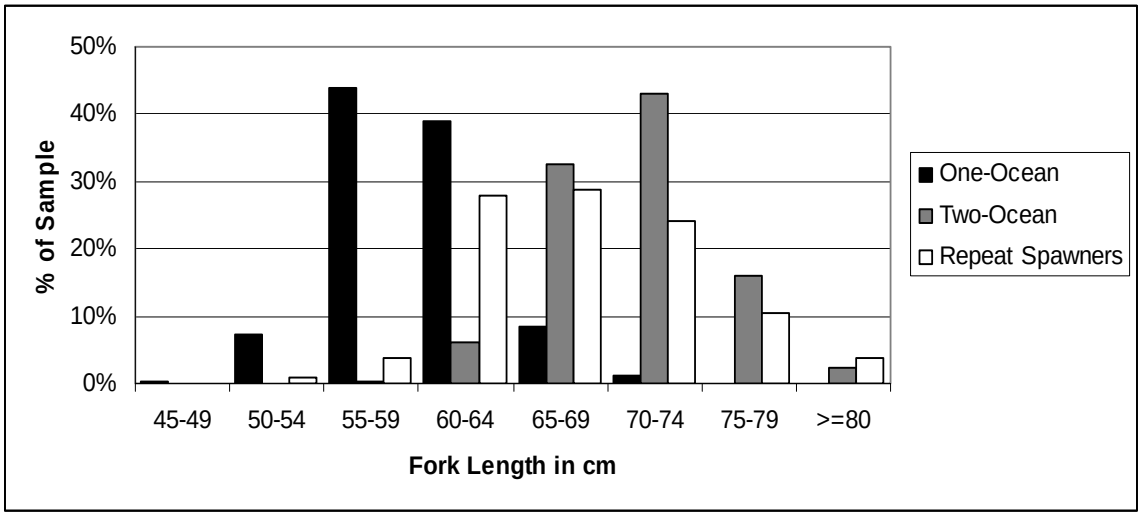
Table 2.13: Spawning locations of known-age steelhead by population, 1990-92

Total Age	Satus Spawners		Naches Spawners		Toppenish Spawners		Yakima Spawners		Total Aged Fish	
	No.	%	No.	%	No.	%	No.	%	No.	%
1.1	3	7.9		0.0		0.0		0.0	5	5.1
1.2	10	26.3	2	10.5		0.0	1	20.0	24	24.2
1.3		0.0		0.0		0.0		0.0	1	1.0
2.1	10	26.3	4	21.1	1	12.5	2	40.0	20	20.2
2.2	15	39.5	11	57.9	6	75.0	2	40.0	45	45.5
2.3		0.0	2	10.5	1	12.5		0.0	3	3.0
4.1		0.0		0.0		0.0		0.0	1	1.0
Totals	38	100	19	100	8	100	5	100	99	100

Size of Returning Adults

Fork lengths of returning steelhead measured at the Prosser Denil and Roza Trap from 2001 to 2006 ranged from 49 cm to 88 cm. Length is associated with ocean age, with an average of 60 cm for fish that have passed one winter at sea, 71 cm for fish that have passed two winters at sea, and 68 cm for repeat spawners. Figure 2.9 shows the distribution of spawners by ocean age.

Figure 2.9: Size class by ocean age



Survival Rates of Upstream Migrants

The only Yakima-population specific data on survival during the upstream migration comes from a very limited number of PIT tag detections.[21] For the period spanning the 2003-04 to 2006-07 return years, 60 of 75 Yakima-origin PIT-tagged adult steelhead (80%) that were detected moving upstream past Bonneville were subsequently detected at McNary Dam. Three of those 60 strayed to the Snake or Upper Columbia, for a total of 57 of the 75 (76%) known to have survived from Bonneville to above McNary and presumed to have entered the Yakima River.

PIT tag detectors have been in place on all three fish ladders at Prosser Dam since August 30, 2005. Of the 16 Yakima-origin adults detected at McNary between August 2005 and June 2007, 13 (81%) were detected at Prosser and 1 at Priest Rapids (6%). Two (12%) were not detected again above McNary.

According to this very preliminary analysis, 80% of tagged fish passing Bonneville are known to have survived to above McNary and 20% died, strayed into other tributaries between Bonneville and McNary, or passed upstream or back downstream undetected. Of those PIT-tagged Yakima origin fish passing McNary, 81% passed Prosser into the Yakima Basin, 6% are known to have strayed into upstream areas, and 12% died, strayed into other tributaries to the McNary Pool, passed upstream undetected, or entered the Lower Yakima River but did not pass Prosser. Multiplying the 80% confirmed passage from Bonneville to McNary by the 81% confirmed passage from McNary to Prosser gives an estimated rate of confirmed passage from Bonneville to Prosser of 65%.

A portion of the losses is attributable to harvest in tribal fisheries and incidental mortality in recreational fisheries in the Columbia River above Bonneville. NOAA Fisheries estimates that overall harvest rates of Middle Columbia steelhead in tribal fisheries average of 4.8% of the run (NMFS 2008, Sec. 6.3.7). Detection failure may account for

[21] Analysis based on data from the DART database http://www.cbr.washington.edu/dart/dart.html

some, but not all, of the remaining loss between Bonneville and McNary. Of 57 fish detected at McNary in all return years, 4 had not been detected at Bonneville, a 7% detection failure. However, all of the 19 adults detected at Prosser since the first ladder went on line had been detected at McNary, indicating that detection rates at McNary are high.

These preliminary survival estimates differ significantly from the estimate of 90% survival from Bonneville to tributaries commonly used. While the analysis presented here relies on a small and short-term dataset and should be considered preliminary at best, the results highlight the need for empirical population-specific estimates of survival rates for the upstream migration of both specific populations and the Middle Columbia River Steelhead DPS as a whole.

Our only estimates of pre-spawning mortality of returning adults within the Yakima Basin come from radio-tracking studies. Of the 194 fish tracked by Hockersmith, 3.6% were confirmed to have died during migration and winter holding, 4% were harvested, and 9% were lost due to either harvest or failed transmitters prior to spawning (Hockersmith et al. 1995). Karp notes that 5 of 93 fish (5%) tagged at Roza in 2002-3 were lost to anglers and 7 of 105 fish (7%) tagged at Roza in 2003-4 were presumed lost to anglers or otters (Karp et al. 2003; Karp et al. 2005). Yakama Nation redd survey teams have also observed otter kills on Satus Creek. These studies support manager's estimates of approximately 10% mortality between passage at Prosser and spawning.

2.5.2 Spawning

Distribution of Spawning

Steelhead spawn across a broad seasonal and geographic range in the Yakima Basin, although based on intrinsic potential analysis and on planners' professional judgments, the current spatial distribution is significantly decreased from historic conditions. Spawning locations include intermittent streams, mainstems, and side-channels of larger rivers, and perennial streams up to relatively steep gradients (Hockersmith et al. 1995; Pearsons et al. 1996). Most Yakima steelhead are tributary spawners, although the distribution of redds throughout the basin is highly variable from year to year and significant amounts of mainstem spawning are known to occur.

Table 2.14 shows spawning locations identified in the Hockersmith radio-tracking study in the early 1990s. At that time 10 spawning areas (Satus Creek, Toppenish Creek, Marion Drain, Naches River, the mainstem Yakima River below Roza Dam, the mainstem Yakima River in the Roza Canyon, Taneum Creek, Swauk Creek, the upper Yakima River [above Ellensburg], and the Teanaway River) were identified.

Table 2.14: Known spawning locations from 1990 to 1992 radio tracking

Location			Number	Percent
Satus Creek				
	Satus Creek		30	28%
	Logy Creek		8	7%
	Dry Creek		11	10%
	Wilson-Charlie Creek		1	1%
		Total	*50*	46%
Toppenish Creek				
	Marion Drain		2	2%
	Toppenish Mainstem		12	11%
		Total	*14*	13%
Naches				
	Naches Mainstem		29	27%
	Little Naches		1	1%
	Bumping River		3	3%
	Rattlesnake Creek		1	1%
	Mainstem Yakima		5	5%
		Total	*39*	36%
Upper Yakima				
	Mainstem in Roza Canyon		3	3%
	Teanaway		2	2%
	Upper Yakima Mainstem		1	1%
		Total	*6*	6%
		TOTAL	109	100%

Population-specific spawning location information comes from a variety of sources. For the Satus Creek watershed, the Yakama Nation has surveyed accessible reaches since 1988. No surveys of mainstem spawning outside of the Satus Creek drainage have been conducted; there are anecdotal accounts of limited spawning in mainstem and lower

sections of Spring and Corral creeks and Amon Wasteway.[22] For the Toppenish Creek Population, redd counts initiated in 1989 by the Yakama Nation give a detailed picture of spawning distribution.

For the Naches Population, the Yakama Nation has conducted redd surveys in Ahtanum Creek since 2000. Since 2004, the USFS, WDFW, USFWS, the Yakama Nation, and others have worked together to survey portions of the Naches drainage (Table 2.15). This information has greatly improved our understanding of spawning distribution in the Naches basin, but inconsistent survey conditions due to high flows and poor visibilities (especially in 2006) limit their use in estimating abundance. No surveys have been conducted in the lower mainstem of the Naches and the associated reaches of the mainstem Yakima. Figure 2.5 shows surveyed redd locations for recent years.

Table 2.15: Naches redd survey results

	2004	2005	2006*	2007	2008	2009
Little Naches River	27	70	4	16	Ns	Ns
Bumping River	2	16	11	Ns	Ns	Ns
Nile Creek	33	20	2	13	8	20
Rattlesnake Ck & Tribs	14	26	1	Ns	Ns	Ns
Oak Creek	18	2	1	15	3	9
American River	Ns	4	0	Ns	Ns	Ns
Cowiche Creek	Ns	2	Ns	Ns	Ns	Ns
Total	**94**	**138**	**19**	**44**	**11**	**29**

*Poor survey conditions

Our primary source of information on spawning locations for the Upper Yakima population comes from 2002 to 2006 radio-tracking surveys (Karp et al. 2003; Karp et al. 2005; Karp et al. 2009). Spawning locations are given in Table 2.16. The high proportion of mainstem spawners (87 of 183 spawners, or 48% for 2002-2004) is striking. The Teanaway system and Swauk Creek are the most consistently used tributary spawning areas.

[22] Spring, Corral, and Snipes creeks and Amon Wasteway are referred to by the names used on the USGS 7.5 minute topographic maps. The first three are referred to as drainageways by local irrigation districts, while Amon Wasteway is often referred to as Amon Creek. The use of these names in this document is in no way meant to indicate any conclusions regarding ongoing disputes about the legal status of these waterways.

Table 2.16: Presumed spawning locations of steelhead tracked by Karp et al. (2009)

Location of Presumed Spawning	Number of Radio-tagged Steelhead
Mainstem Yakima River[1]	133 (37.7%)
Teanaway River	137 (38.8%)
Swauk Creek	46 (13.0%)
Taneum Creek	17 (4.8%)
Cle Elum River	12 (3.4%)
Lower Naches River, Umtanum, Cherry, Naneum, and Wilson creeks	8 (2.3%)
Total tributary	220 (62.3%)
Total	353

Timing of Spawning

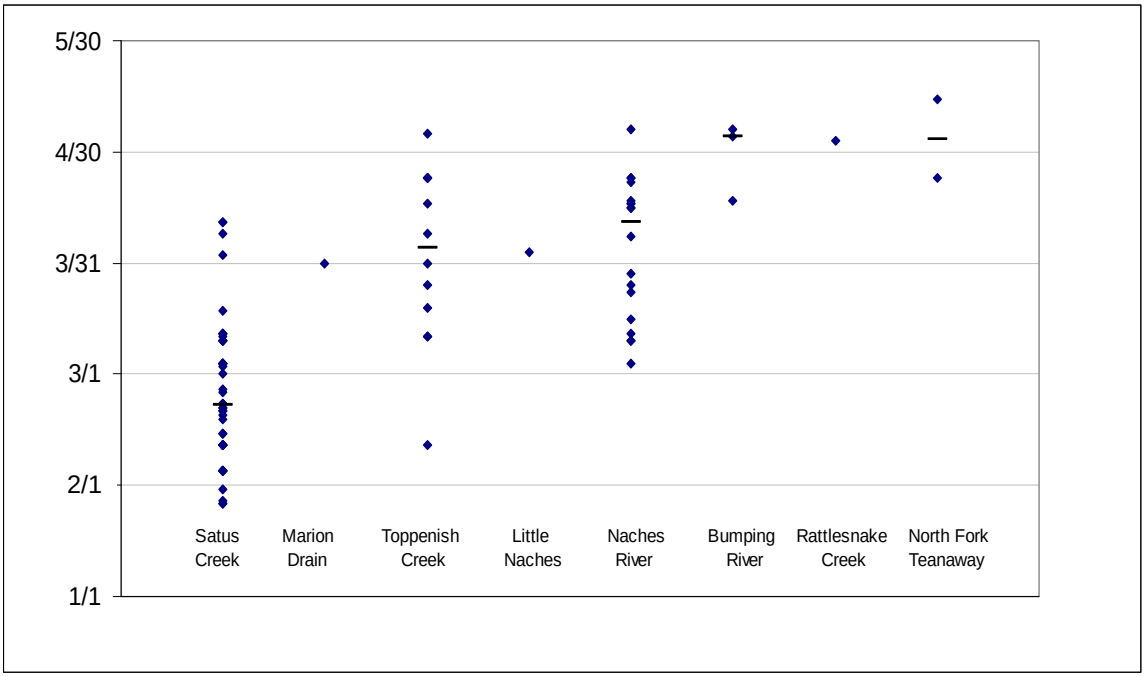
Based on radio tagging and redd surveys, most spawning is completed between late January and mid-May. Figure 2.10 shows spawning dates by tributary for the 86 steelhead tracked to spawning in 1990-1992 (Hockersmith et al. 1995). In Satus Creek and its tributaries, the median spawning date was more than a month earlier than in any of the other tributaries, with spawning beginning in late January and predominantly occurring in February and March. In Toppenish Creek and the Naches spawning occurred mostly in March and April, while spawning in higher elevation tributaries occurred in late April and May.

Fecundity

Yakima steelhead have a relatively high fecundity in spite of their small size. Broodstock collected for species interaction experiments in brood years from 1986 to 1993 carried an average of 5,100 eggs (Fast and Berg 2001).[23]

[23] A length/fecundity relationship of # eggs = 189.28 x Fork Length in cm—6449 was calculated based on data from broodstock collected from the 1988-89 return (Chris Fredrickson, Yakama Nation, personal communication).

Figure 2.10: Individual and median dates for spawning initiation 1990-1992



2.5.3 Role of Kelts

Steelhead can return to the ocean after spawning and return to spawn again. During their return to the ocean they are called kelts. In spawning areas near the ocean, rates of repeat spawning can be as high as 79%. Natural rates of repeat spawning for Interior Columbia steelhead populations are unknown. Recent rates range include 17% for the Kalama River, 4.6% for the Hood River, 2-9% in the Walla Walla, and 1.5% in the Upper Columbia River (Branstetter et al. 2005). Natural repeat spawning by Yakima Basin steelhead is extremely limited; scale analysis in 1990-1992 indicated that 1.6% of returning adults were repeat spawners in the 1990-1992 brood years (Hockersmith et al. 1995). It is hypothesized that the development of the mainstem Columbia hydropower system and the associated passage impediments, reduced spring flows, and increased temperatures have reduced kelt survival rates.

Kelts typically migrate downstream from spawning areas in March through June. Kelts have been observed at the Chandler Juvenile Enumeration Facility (RM 47.1) into the middle of July, but water temperature approaches lethal levels by that time even in normal water years. Temperatures do not return to safe levels until early autumn (Fast and Berg 2001). Out-migration of kelts from the upper basin may be especially hazardous because later spawning dates combine with increased travel distance as the Yakima and Columbia rivers warm and their flow declines.

To increase the contribution of repeat spawners to steelhead productivity in the basin, the Yakima-Klickitat Fisheries Project initiated kelt reconditioning experiments in 2000 with funding from BPA. Post-spawning steelhead are captured as they pass through the Chandler Juvenile Facility at Prosser Dam on their downstream migration. From 2000 to 2006, between 15 and 37% of the upstream adult count were captured (the remaining fish

either pass over Prosser Dam or it ladders without entering the juvenile facility or do not migrate downstream) (Table 2.17). Over 90% of collected kelts are female.

Table 2.17: Numbers of kelts[24]

Year	Collected	% of run	In-river	No-term	Reconditioned	Short-term	Long-term	Mortalities
2000	512	37%	0	0	512	0	91	421
2001	551	19%	0	0	551	0	108	443
2002	1113	25%	0	0	899	334	140	425
2003	826	37%	0	0	690	187	298	205
2004	966	35%	0	64	779	83	216	480
2005	808	23%	67	96	541	96	65	380
2006	520	26%	53	49	348	50	85	213
2007	567	37%	53	38	465	38	221	206
2008	855	26%	88	100	600	100	266	234

Captured kelts are put into one of four groups: in-river, no-term, short-term, and long-term. In-river kelts are tagged and returned directly to the Yakima River to continue their downstream voyage. This treatment was established in 2005 to develop better estimates of current rates of natural repeat spawning (Branstetter et al. 2005). No-term kelts are tagged and immediately transported to release sites below Bonneville Dam. Short-term kelts are held and fed in the hatchery for three to five weeks prior to being released below Bonneville, while long-term kelts are held and fed for six to nine months prior to being released in the lower Yakima River prior to the next spawning season.

The program is currently the only hatchery program for Yakima steelhead stocks. It is estimated to have increased the number of spawning steelhead in the Yakima Basin by 7% (David Lind, Yakama Nation, personal communication, 2008.). The basin's most famous kelt was captured and PIT-tagged as an adult headed above Roza Dam in 2002, then recaptured in 2003 and radio tracked to spawning in Swauk Creek. She then traveled downstream to Chandler where she was reconditioned, and after release, was tracked back to the same reach of Swauk Creek (Karp et al. 2003; Karp et al. 2005). That is over 1,500 miles of in-river migration by a single fish!

Efforts to evaluate the reproductive success of reconditioned kelts began in 2004 (Branstetter et al. 2005). The effects of the kelt reconditioning program on the steelhead populations' genetic and life history diversity are unknown, but thought to be minor due to the natural origin of the fish themselves and the volitional release strategy that allows the reconditioned kelts to naturally select spawning sites. This issue is being investigated using genetic sampling and radio tracking of reconditioned adults.

2.5.4 Incubation and Emergence

Unlike other species in the *Oncorhynchus* genus, steelhead eggs incubate as temperatures increase. Hatching time varies with water temperature, region, habitat, and season (Bjornn and Reiser 1991). The timing of steelhead fry emergence in the Yakima Basin is poorly understood. Field studies indicate that 50% of steelhead trout in a redd will have

[24] Based on annual reports from BPA Project # 200001700 (Branstetter et al. 2005)

emerged when roughly 1,300 cumulative temperature units have been acquired. [25] Based on this relationship, fry emergence would occurs as follows (Yakima Subbasin Fish and Wildlife Planning Board 2005):

- Satus Creek: early May to early June
- Toppenish Creek: late May through early July
- Lower Naches and Cowiche: early June through mid-July
- Upper Naches: mid June through mid-July
- Upper Naches tributaries: late June through late July
- Middle Yakima and tributaries: early June through early July
- Mainstem in Yakima Canyon (including tributaries): early June through early July
- Upper Yakima mainstem above the Yakima Canyon: mid June through late July
- Upper Yakima tributaries: late June through early August

2.5.5 Juvenile Rearing

Juvenile steelhead spend from one to three years in fresh water before migrating to the Pacific Ocean. Juveniles use tributary and mainstem reaches throughout the Yakima Basin as rearing habitat, until they begin to smolt and leave the basin. Some juveniles leave their natal areas and may spend considerable time from fall to spring rearing in areas that may have been inhospitable in the summer.

Juvenile rearing conditions significantly affect the size and condition of outmigrating smolts. For example, Yakama Nation smolt trap data indicate that steelhead from Ahtanum Creek were substantially larger than those in Satus and Toppenish creeks in each age class in both seasons sampled. This higher growth rate may be related to lower rearing density and more favorable discharge and temperature for growth in late summer.

Data from Toppenish Creek smolt traps demonstrate the value of seasonal rearing habitat. Five juveniles that were tagged prior to March 1 in a section of Toppenish Creek not hospitable to summer rearing were recaptured an average of 85 days later only 28 km downstream, and had tripled their average weight, indicating the potential significance of lower Toppenish Creek for pre-smolt rearing, despite substrate too fine for spawning and water temperatures that preclude summer use.

Cramer et al. (2003; 2004) have used stock-recruit relationships to argue that Yakima Basin steelhead production is limited by juvenile capacity, assuming habitat capacity above Roza Dam is naturally predisposed to produce resident *O. mykiss*. (See below.)

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[25] Cumulative temperature units are calculated by summing the daily average degrees Celsius over the number of days from spawning to emergence.

2.5.6 Resident/Anadromous Interactions

Offspring of steelhead can residualize in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. This dynamic expression of life-history characteristic makes *O. mykiss* very challenging to understand and manage. For an overview of the current understanding of the range of interactions between resident and anadromous *O. mykiss*, see Chapter 2 of WDFW's recent draft assessment of steelhead status (Scott and Gill 2006) and NOAA Fisheries' Salmon Recovery Science Review Panel Report on the topic (Salmon Recovery Science Review Panel 2004). Generally, the anadromous form of *O. mykiss* dominates the Satus and Toppenish populations, while the resident form currently dominates the Upper Yakima. In the Naches population, both anadromous and resident forms are geographically widespread.

Steelhead/resident pairing during spawning has not been noted at any significant levels during Satus and Toppenish Creek redd surveys (Tim Resseguie, Yakama Nation Fisheries, personal communication, 2007) but has been observed repeatedly during redd surveys in the Naches drainage (Gary Torretta, USFS, personal communication, 2007). Pearsons et al. (1998) concluded that ecological and genetic evidence indicated that rainbow and steelhead trout in the upper Yakima interbreed when in sympatry, and document several cases of observed resident/steelhead matings. However during 2004 radio tracking in the Upper Yakima, no resident/anadromous pairs were observed; all 15 observed pairings were between male and female steelhead, and occurred in tributaries (Teanaway, Taneum, and Swauk creeks) (Karp et al. 2005).

Cramer et al. (2003; 2004) assert that the Upper Yakima and portions of the Naches drainage would naturally primarily support the resident form of *O. mykiss*. Many others have asserted that the Upper Yakima would once have been a major producer of anadromous steelhead, and that changes in habitat conditions and introduction of non-native hatchery rainbow trout have greatly reduced the expression of anadromy. Factors hypothesized to contribute to this shift include:

- Reduction in survival rates for outmigrating smolts and returning adults associated with changed flow, predation, and passage conditions in the mainstem Yakima and Columbia that reduces the fitness of the anadromous life history relative to residents
- Reduction in temperatures and increases in flow in mainstem habitat reaches associated with irrigation delivery flows increasing the relative benefits of residency
- Loss of access to tributary habitat with conditions that promote anadromy
- Reduction of mainstem habitat quality for year-0 juveniles due to simplified channels, high summer velocities associated with irrigation delivery flows and rapid changes in flows associated with flip-flop
- Possible introgression of genes from non-anadromous hatchery trout and steelhead introductions

Genetic analysis indicates that in specific Upper Yakima tributaries, the anadromous and resident forms of *O. mykiss* are genetically more similar to each other than to the same life history in other tributaries, while the trout population in the mainstem is both genetically distinct from tributary *O. mykiss* and shows signs of introgression from hatchery stocks (Pearsons et al. 2007).

Based on the goal built into NOAA Fisheries' policy of conserving the anadromous component of *O. mykiss* as a Distinct Population Segment, interactions between resident and anadromous *O. mykiss* can have both positive and negative outcomes. The ICTRT viability framework identifies a significant shift by a predominantly anadromous population to increased residency as a factor that increases the extinction risk of the anadromous portion of the population.

The ability of resident males to successfully breed with anadromous females and produce anadromous offspring can significantly increase the effective population size of the anadromous population, especially when spawner abundance is low, and can increase the resilience and persistence of the population.

The ability of resident-resident pairings to produce anadromous offspring can also allow for re-establishment of an anadromous run in the absence of anadromous spawners. While this is known to occur, and may be an important survival mechanism for temporarily isolated populations, the persistence of this trait after many generations without anadromous returns contributing to the gene pool is unknown (Salmon Recovery Science Review Panel 2004; Scott and Gill 2006). Thrower (2004) found, however, that a resident population continued to produce smolts despite 70 years of isolation from anadromous adults. Thrower's results indicate that the correlation between smoltification and other traits associated with fitness in the freshwater environment provide a mechanism to explain how a low level of smoltification could persist despite the loss of all smolts from the isolated population. However, this example is only 70 years old, which is fairly short from an evolutionary perspective. If the ability is retained, it is likely that interim absence of selection for traits favorable to anadromy may result in loss of these traits (Thrower 2004).

The impacts of competitive interactions between larger resident individuals and juvenile anadromous *O. mykiss* may also reduce the production of smolts, especially where habitat conditions have shifted to promote residency.

The nature of the relationship between resident and anadromous forms is inherently complex. Setting realistic goals for steelhead production in different parts of the Upper Yakima and Naches systems will require an improved understanding of the range of interactions between resident and anadromous life histories. This is identified as a key knowledge gap in Chapter 7.

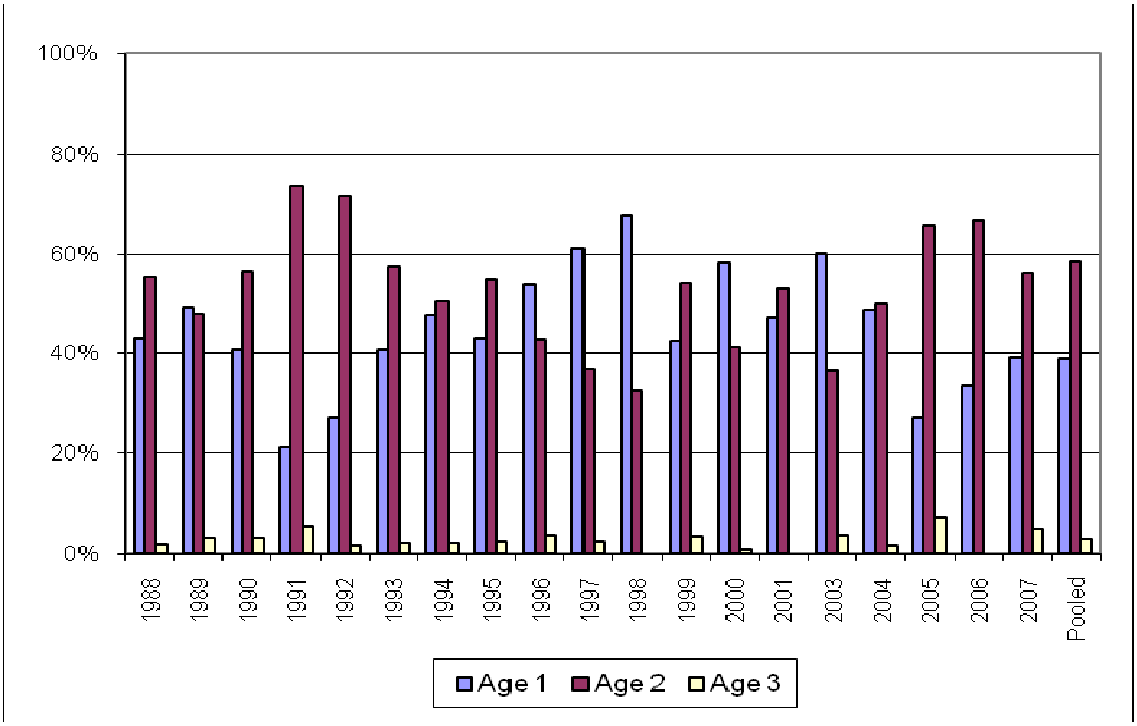
2.5.7 Smolt Outmigration

Age and Size at Outmigration

Steelhead smolt ages at Prosser Dam are shown in Figure 2.11 below, which is derived from more than 9,000 age determinations from 1988 through 2004. Overall, 39% of the

sample was age one, 58% was age two and 3% was age three. The percentage of age one steelhead smolts passing Prosser Dam (Fig. 2.1) is unusually high for an interior population (Peven et al. 1994). The age distribution of outmigrating smolts differs from the freshwater age distribution of returning adults (15% age one, 75% age two and 10% age three (calculated from Figure 2.11 and excluding repeat spawners), indicating significantly better survival from smolt to returning adult for older smolts. (Some of the difference could also be explained by smolts spending another winter in freshwater below Prosser Dam; however, this is not a known life history for Yakima Basin steelhead.)

Figure 2.11: Steelhead smolt ages at Prosser Dam



Very little data exist to estimate age at outmigration for specific populations. Based on scale samples from juvenile steelhead trapped by the Yakama Nation in Satus, Toppenish, and Ahtanum creeks during the 2001-02 and 2003-04 out-migration seasons, age one smolts appeared to be more prevalent than age two in Satus and Toppenish creeks, and age three smolts were uncommon in all three creeks. Table 2.18 shows the average size by smolt age for outgoing smolts sampled at the Chandler juvenile facility at Prosser.

Table 2.18: Size in millimeters for outmigrating smolts at Prosser by age class

Year	1	2	3	4
1988	147	187	210	
1989	155	189	217	
1990	133	179	220	
1991	148	179	210	300
1992	160	190	232	
1993	137	183	216	
1994	127	170	235	
1995	151	179	209	
1996	136	181	226	
1997	152	189	208	
1998	131	173		
1999	137	178	247	
2000	162	183	255	
2001	174	198		
2003	132	194	243	
2004	136	186	195	
2005	179	195	206	
2006	139	204		
2007	160	202	236	
Average	**147**	**186**	**223**	

Abundance of Outmigrants

Prosser Dam is located downstream of almost all steelhead spawning areas in the Yakima Basin. A juvenile fish counting facility is built into the fish screen bypass system, enabling both PIT tag detections and manual counts of entrained fish. Steelhead mark-and-recapture studies have not been conducted at Prosser Dam since before the June 23, 1999 listing of Middle Columbia River steelhead. Instead, steelhead passage is estimated by applying entrainment, canal mortality, and sampling rate coefficients established for spring Chinook to manual counts of steelhead at the Prosser Juvenile Facility. The degree of bias introduced by this substitution is not known, but may be significant. For this reason, annual steelhead smolt counts are not considered reliable enough for year-to-year comparisons of the number of outmigrants. Estimates of the number of steelhead smolts passing Prosser Dam have ranged between 25,000 and 50,000 smolts between 1999 and 2005 (2006 counts were hampered by high flows).

Timing of Outmigration

As noted in Section 2.5.4, some juveniles leave their natal areas and may spend considerable amounts in the fall through spring rearing in areas that may have been inhospitable in the summer. Others move fairly rapidly from their initial rearing areas towards the Columbia. Juvenile outmigration through the lower Yakima River and past Prosser Dam begins in November and peaks between mid-April and May. The timing of

the overall steelhead outmigration at McNary and Bonneville dams parallels the timing at Prosser, and runs from early April through the end of June. Steelhead smolts have been observed passing Prosser into the middle of July, but the Lower Yakima has warmed to lethal temperatures by that time even in normal water years and typically does not cool again to safe levels until early autumn (Fast and Berg 2001). Little information is currently available to determine if the timing of outmigration differs by population. Steelhead tagged in Satus Creek in the 2003-04 and 2004-05 seasons arrived earlier at Prosser Dam than smolts tagged in Toppenish Creek or Ahtanum Creek (Table 2.19).

Table 2.19: Steelhead travel times from tributary tagging locations to Prosser Dam

		Mean Dates	
Release Year	Trap Location	Release	Prosser
2003-04	Toppenish	2/10/04	4/24/04
2003-04	Ahtanum	4/8/04	5/8/04
2003-04	Satus	3/25/04	4/20/04
2004-05	Toppenish	3/12/05	4/25/05
2004-05	Ahtanum	3/25/05	5/5/05
2004-05	Satus	2/27/05	4/7/05

Survival Rates for Outmigrants

A series of PIT tag groups used for entrainment rate studies at Prosser Dam in the relatively high-flow year of 1999 were used to estimate juvenile steelhead survival rate of 0.798 to McNary Dam by Williams et al. (2005). Subsequent years' survival estimates to McNary Dam by the authors were lower, (0.314 in 2002 and 0.394 in 2003), and were likely derived from the 2001-02 and 2002-03 Toppenish Creek releases described below, thus having a point of origin well upstream from Prosser Dam.

The Yakama Nation operates screw traps in Satus, Toppenish, and Ahtanum creeks, but widely fluctuating flows and heavy debris loads during the out-migration period hamper passage estimation at these locations. Toppenish Creek steelhead have been PIT tagged since the 2001-02 out-migration season, giving an opportunity to estimate downstream survival and return rates of tag groups. PIT tagging at the Ahtanum and Satus creek traps began in the 2003-04 season.

Downstream survival rate of PIT-tagged juvenile steelhead to Prosser Dam can be estimated by dividing Prosser detections by Prosser entrainment rate on the date of each detection (using the aforementioned diversion-entrainment relationship) and also by using PIT tag detections at the McNary Dam juvenile bypass to calculate the Prosser entrainment rate. Table 2.20 shows tagging data and estimated survival rates. Calculated survival rates from tributaries to Prosser range from 14% to 74%.

Table 2.20 supports the hypothesis that steelhead smolt survival rate to Prosser is related to travel distance. Fish from the Satus Creek trap, which is closest to Prosser Dam, survived best, while estimated survival rates from the Toppenish and Ahtanum creek traps were both lower, and much lower from Toppenish Creek in the drought year of 2005. Within Toppenish Creek, survival rates were lower for upstream releases, especially in the 2001-02 outmigration period. There is a strong tendency for later out-

migrants to travel faster downriver. Better understanding of the relationship between flows, habitat conditions, and outmigration timing and survival is identified as a key knowledge gap in Chapter 7.

Table 2.20: Survival rates of steelhead smolts from selected tributaries

										Adult Return Rate (%)					
Outmi-gration Season	Stream	Km To McNary Dam	Tagging Dates		Number Tagged	Juvenile Survival Rate to McNary (%)[1]		Adult Returns to McNary		Tributary Smolt To McNary Adult			McNary Smolt to McNary Adult[2]		
			Begin	End		Survival Rate	Standard Error, +/-	Age 1	Age 2	Age 1	Age 2	Total	Age 1	Age 2	Total
2002	Toppenish	247	12/5/01	5/22/09	955	29	7	9	2	0.94	0.21	1.15	3.29	0.73	4.02
2002	Toppenish	219	2/21/02	5/24/02	292	58	22	9	2	3.08	0.68	3.77	5.29	1.18	6.47
2003	Toppenish	247	11/12/02	3/3/03	575	40	11	11	2	1.91	0.35	2.26	4.78	0.87	5.65
2003	Toppenish	219	3/30/03	5/19/03	196	28	8	4	1	2.04	0.51	2.55	7.38	1.85	9.23
2004	Toppenish	247	12/10/03	5/5/04	467	28	11	3	0	0.64	0.00	0.64	2.33	0.00	2.33
2004	Toppenish	219	12/24/03	5/2/04	671	20	6	4	1	0.60	0.15	0.75	2.95	0.74	3.68
2004	Ahtanum	246	1/16/04	5/5/04	247	43	26	1	0	0.40	0.00	0.40	0.95	0.00	0.95
2004	Satus	183	1/13/04	5/5/04	61	47	25	1	0	1.64	0.00	1.64	3.51	0.00	3.51
2005	Toppenish	247	12/13/04	5/26/05	1420	14	6	9	2	0.63	0.14	0.77	4.69	1.04	5.73
2005	Ahtanum	246	12/14/04	5/21/05	386	10	3	0	1	0.00	0.26	0.26	0.00	2.60	2.60
2005	Satus	183	12/17/04	4/24/05	160	20	8	0	0	0.00	0.00	0.00	0.00	0.00	0.00
2006	Toppenish	247	12/24/05	5/30/06	685	30	5	9	0	1.31	0.00	1.31	4.40	0.00	4.40
2006	Ahtanum	246	1/13/06	6/6/06	95	48	19	1	0	1.05	0.00	1.05	2.18	0.00	2.18
2006	Satus	183	12/27/05	5/25/06	176	68	14	2	1	1.14	0.57	1.70	1.66	0.83	2.49

[1]Calculated by PitPro 4 (PitTag Processor), Columbia Basin Research, University of Washington

[2]McNary smolts estimated from total releases multiplied by survival rate estimates to McNary

[3]released from two locations on Snake Creek, a lower Toppenish Creek distributary

2.5.8 Ocean Residence

Yakima Basin steelhead typically spend between one and three years in the ocean before returning to natal streams to spawn, as detailed in the discussion of age structures in Section 2.5.1.2. Variability in estuary and ocean conditions is a major driver of year-to-year survival and growth of adult steelhead. Variation occurs because of changing climatic conditions, fisheries impacts (presumed minimal for the Middle Columbia Steelhead DPS), possible density-dependant competitive interactions with other salmon species and hatchery fish, and variability of prey and predator abundance. NOAA Fisheries' Middle Columbia Steelhead Recovery Plan will address ocean and estuary effects on the Middle Columbia River Steelhead DPS as a whole. The only specific data about ocean survival rates of Yakima Basin steelhead comes from analysis of return rates of PIT-tagged smolts detected during their downstream and subsequent upstream migrations. Preliminary estimates show McNary smolt to McNary adult return rates of 2.5% to 6.3%; general experience with PIT tag returns shows that they typically underestimate smolt to adult survival rates for the untagged portion of the run (FPC (Fish Passage Center) and Comparative Survival Study Oversight Committee 2006). Future efforts to assess the impacts of size, age, and condition of outmigrating smolts on ocean survival rates will help guide efforts to manage conditions within the Yakima Basin in a manner that improves ocean survival of outgoing smolts.

2.6 Viability Assessments for Yakima Basin Steelhead

Several efforts have been made to assess the current status of steelhead in both the Yakima Basin and the Middle Columbia DPS as a whole. At the time of the initial listing under the ESA in 1999 (64FR14517 and Busby (1996)), habitat degradation, low

abundance, declining productivity, and the threat of hatchery practices to genetics of native stocks were identified as the primary factors justifying listing.

Cramer et al. (2003; 2004) have emphasized that Yakima Basin steelhead are minimally affected by intermixing with hatchery spawners, that abundance and productivity trends improved significantly between the mid-1990s and 2004, and that steelhead production from parts of the basin may be limited by conditions that promote residency. They assert that steelhead are fully seeding currently available habitat and that the availability of rearing habitat is limits production. They do not address the degree to which improvements in existing habitat and increased access to currently inaccessible habitat could increase juvenile habitat capacity nor do they address how improvements in survival rates in migratory life stages (smolt and adult) could change the adult abundance supported by a given smolt production capacity.

This plan incorporates the viability assessments developed by the ICTRT in 2004 through 2007 based on the Viable Salmonid Population conceptual framework (McElhany et al. 2000). The ICTRT Stock Status Assessments for the Yakima Basin (ICTRT In press) were prepared in accordance with ICTRT guidelines (ICTRT 2004a; 2004b; 2005a; 2005b; 2007b). Supporting data were drawn from multiple sources, including previous drafts of this recovery plan. These analyses are based on the best information available. While this information is at times limited, the stock status assessments represent a solid effort to utilize existing data to evaluate viability. As noted in Chapter 7, these assessments should be updated as our ability to determine population-specific VSP parameter improves.

Table 2.21 shows the results of the ICTRT analysis: the Satus and Toppenish populations were each assigned an abundance/productivity risk of moderate and a Spatial Structure/Diversity risk of moderate. The Naches population was assigned a high abundance/productivity risk and a Spatial Structure/Diversity risk of moderate. The Upper Yakima was ranked high for both risk classes. The rest of this section reviews the ICTRT’s basis for these assignments.

Table 2.21: ICTRT risk ratings for Yakima steelhead populations

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/ Productivity Risk	**Very Low** (<1%)	**HV**	**HV**	**V**	**M**
	Low (1–5%)	**V**	**V**	**V**	**M**
	Moderate (6–25%)	M	M	M **Satus/ Toppenish**	
	High (>25%)			**Naches**	**Upper Yakima**

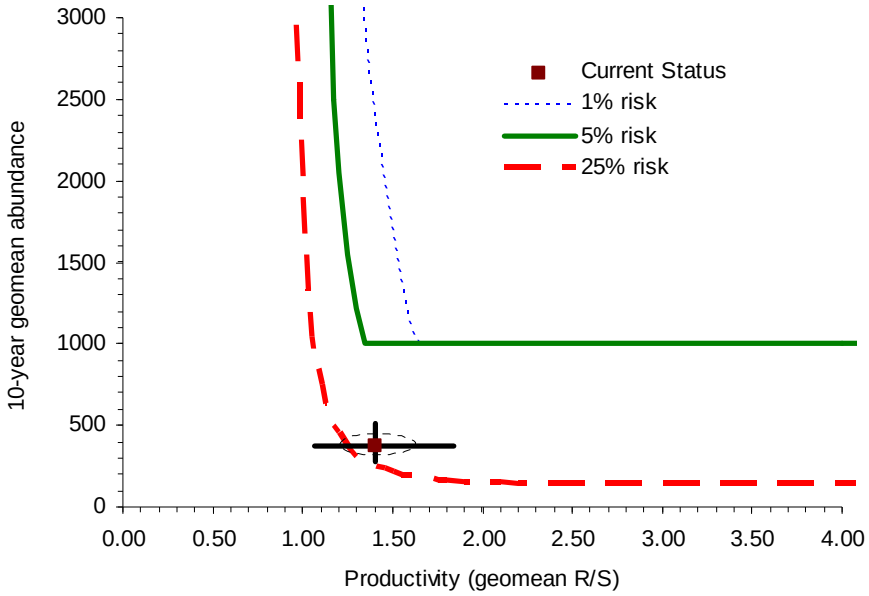
Viability Key: HV = Highly Viable; V = Viable; M = Not Viable, Candidate for Maintained Status

2.6.1 Satus Creek

Abundance and Productivity

The ICTRT classified the Satus Creek steelhead population as “Intermediate” in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 1,000 wild spawners with sufficient productivity (greater than 1.35 returns per spawner at the abundance threshold) to avoid a 5% extinction risk on the ICTRT’s viability curve. With a 10-year (1996-2005) geomean abundance of 379 and a delimited/adjusted productivity value of 1.40 returns per spawner, the Satus Creek steelhead population is deemed to be at moderate risk of extinction, i.e., between the 5% and 25% risk lines for an intermediate-size population (Figure 2.12).

Figure 2.12: Satus abundance & productivity compared to the viability curve



Curve is for an intermediate-sized population. The point estimate includes a 1 standard error ellipse and 95% confidence intervals (1.81 x SE for both productivity and abundance estimates).

Spatial Structure and Diversity

Both MSAs and the MiSA in the Satus Creek drainage are rated as occupied.[26] Table 2.22 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Satus Creek steelhead population at low risk for Goal A, which covers spatial structure factors, and moderate risk for Goal B, which covers genetic and phenotypic diversity. The three metrics contributing to the risk rating under Goal B were phenotypic variation due to constraints on migration timing, distribution across habitat types because of habitat loss in lower Satus Creek, and selective impacts related to migration timing constraints. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of moderate.

According to the ICTRT the population status relative to Goal B could be improved by addressing B.1.b (phenotypic variation). The first step in addressing this component should be a more detailed evaluation of spawning and rearing timing. That assessment should be designed to evaluate the relative change in phenotypic characteristics for the population and the factors driving the shifts. If further analysis confirms a significant shift in phenotypic characteristics relative to the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting, restoration actions should be initiated. Based on this scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

[26] See Section 4.2.3 for the ICTRT definition of “occupancy.”

Table 2.22: ICTRT spatial structure & diversity ratings for the Satus population

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a Number and spatial arrangement of spawning areas</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Low Risk (Mean = 0.66)</td><td rowspan="3">Low Risk</td><td rowspan="15">Moderate Risk</td></tr>
<tr><td>A.l.b. Spatial extent or range of population</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>A.1.c. Increase or decrease in gaps or continuities between spawning areas</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.a. Major life history strategies</td><td>L (1)</td><td>L (1)</td><td rowspan="3">Moderate Risk</td><td rowspan="10">Moderate Risk</td></tr>
<tr><td>B.1.b. Phenotypic variation</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.c. Genetic variation</td><td>VL (2)</td><td>VL (2)</td></tr>
<tr><td>B.2.a. (1) Out-of-DPS spawners</td><td>L (1)</td><td rowspan="4">Low Risk</td><td rowspan="4">Low Risk</td></tr>
<tr><td>B.2.a. (2) Out-of-MPG spawners</td><td>L (1)</td></tr>
<tr><td>B.2.a. (3) Out-of-Population spawners</td><td>VL (2)</td></tr>
<tr><td>B.2.a. (4) Within-population hatchery spawners</td><td>L (1)</td></tr>
<tr><td>B.3.a. Distribution of population across habitat types</td><td>M (0)</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.4.a. Selective change in natural processes or selective impacts</td><td>M (0)</td><td>M (0)</td><td>M (0)</td></tr>
</table>

Overall, the Satus Creek steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate

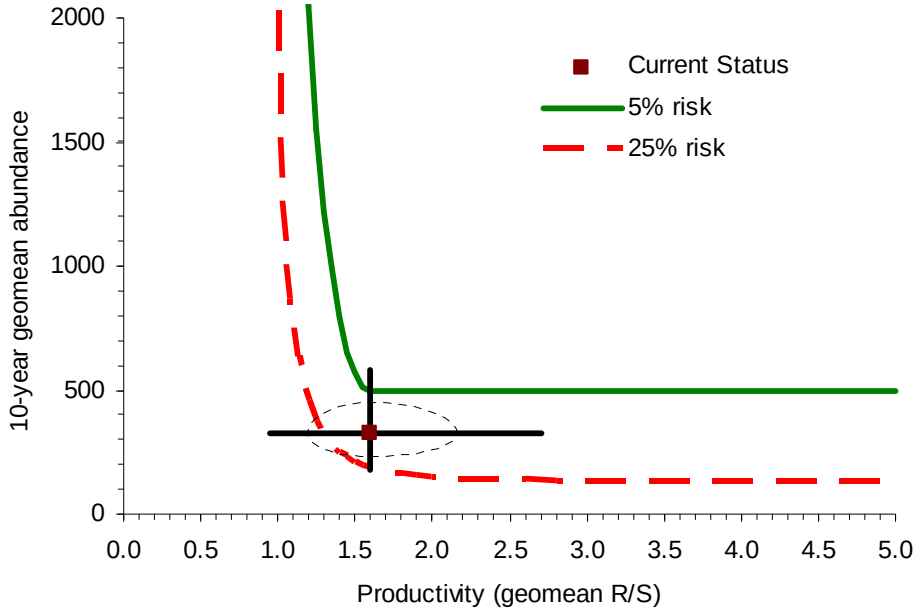
moderate risk. To achieve viable status, the Satus Creek population must exceed the minimum threshold escapement of 1,000. To achieve very low risk status (high viability) the improvement in abundance would need to be accompanied by an increase in productivity and the changes in spatial structure and diversity described above.

2.6.2 Toppenish Population

Abundance and Productivity

The ICTRT classified the Toppenish Creek steelhead population as "Basic" in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 500 wild spawners with sufficient productivity (greater than 1.56 returns per spawner) to avoid a 5% extinction risk on the ICTRT's viability curve. With a 10-year (1996-2005) geomean abundance of 322 and a delimited/adjusted productivity value of 1.60 returns per spawner, the Toppenish Creek steelhead population is deemed to be at moderate risk of extinction, i.e., between the 5% and 25% risk lines for a basic-size population (Figure 2.13).

Figure 2.13: Toppenish abundance & productivity compared to the viability curve



Curve is for a basic-sized population. The point estimate includes a one standard error ellipse and 95% confidence intervals (1.81 x SE for both parameters).

Spatial Structure and Diversity

The ICTRT classifies both MSAs as occupied. Table 2.23 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Toppenish Creek steelhead population at low risk for Goal A, which covers spatial structure factors and moderate risk for Goal B, which covers genetic and phenotypic diversity. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of moderate.

Table 2.23: ICTRT spatial structure & diversity ratings for the Toppenish population

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a Number and spatial arrangement of spawning areas	L (1)	L (1)	Low Risk Mean = 0.66	Low Risk	
A.l.b. Spatial extent or range of population	M (0)	M (0)			
A.1.c. Increase or decrease in gaps or continuities between spawning areas	L (1)	L (1)			
B.1.a. Major life history strategies	M (0)	M (0)	Moderate Risk	Moderate Risk	
B.1.b. Phenotypic variation	M (0)	M (0)			
B.1.c. Genetic variation	M (0)	M (0)			
B.2.a. (1) Out-of-DPS spawners	L (1)	Low Risk (1)	Low Risk (1)		
B.2.a. (2) Out-of-MPG spawners	L (1)				
B.2.a. (3) Out-of-Population spawners	VL (2)				
B.2.a. (4) Within-population hatchery spawners	L (1)				
B.3.a. Distribution of population across habitat types	L (1)	L (1)	L (1)		
B.4.a. Selective change in natural processes or selective impacts	M (0)	M (0)	M (0)		

Since listing of the DPS in 1999, problems with adult passage, juvenile entrainment, and instream flow have been addressed in part through several restoration projects and flow regulation in the agricultural portion of the Toppenish Creek watershed. However, seepage losses (which may be partly of human origin) combine in dry years with agricultural diversions to restrict passage to and from the most important spawning and rearing areas. Summer rearing is also precluded in lower Toppenish and Simcoe creeks. Eggs and fry in Marion and Harrah drains, a new spawning area, are unlikely to survive due to poor habitat and to irrigation spills during the emergence period. This ostensible increase in range may actually increase extinction risk, hence the moderate risk rating under the spatial extent metric.

Under Goal B, risk is elevated with respect to life history strategies given rearing conditions in the lower creek, phenotypic variation because of constraints on adult migration timing, and in genetic variation due to low levels of heterozygosity that may be related to earlier passage bottlenecks. Migration timing constraints and loss of rearing habitat in the lower creek result in moderate risk with respect to the selective impacts metric.

According to the ICTRT, at least two major components of the spatial structure/diversity criteria must be addressed to move this population to a low risk rating. Expansion of the current range into historically utilized rearing areas in the lower reaches of Toppenish Creek would increase the range of life history patterns towards historical levels. The status relative to goal B could be improved by addressing B.1.b (phenotypic variation). The first step in addressing this component should be a more detailed evaluation of spawning and rearing timing. That assessment should be designed to evaluate the relative change in phenotypic characteristics for the population and the factors driving the shifts. If further analysis confirms a significant shift in phenotypic characteristics relative to the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting, restorations actions should be initiated. Based on the ICTRT scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

Overall, the Toppenish Creek steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate moderate risk. To achieve viable status, the abundance of the population must be increased sufficiently to maintain the population above the minimum threshold escapement of 500 spawners. To achieve very low risk status (high viability) those improvements in abundance would need to be accompanied by the changes in spatial structure and diversity described above.

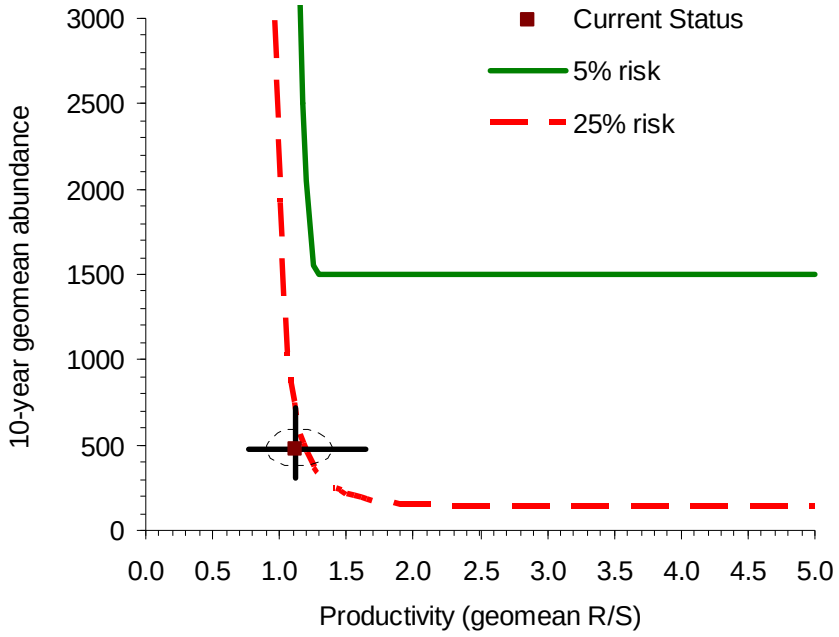
2.6.3 Naches Population

Abundance and Productivity

The ICTRT classified the Naches River steelhead population as “Large” in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 1500 wild spawners with sufficient productivity (greater than 1.26 returns per spawner at the abundance threshold) to avoid a 5%

extinction risk on the ICTRT's viability curve. With a 10-year (1996 to 2005) geomean abundance of 472 and a delimited/adjusted productivity value of 1.12 returns per spawner, the Naches River steelhead population is deemed to be at high risk of extinction, i.e., below the 25% risk line for a large-size population (Figure 2.14).

Figure 2.14: Naches abundance & productivity compared to the viability curve



Curve is for a large-sized population. The point estimate includes a 1 standard error ellipse and 95% confidence intervals (1.81 x SE for both productivity and abundance estimates).

Spatial Structure and Diversity

The ICTRT classified seven of eight MSAs in the Naches Population area as occupied (the Cowiche MSA was rated as unoccupied). Table 2.24 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Naches River steelhead population at low risk for Goal A, which covers spatial structure factors, and moderate risk for Goal B, which covers genetic and phenotypic diversity. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of moderate.

Table 2.24: ICTRT spatial structure & diversity ratings for the Naches population

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a Number and spatial arrangement of spawning areas	VL (2)	L (2)	Low Risk Mean = 1.33		
A.l.b. Spatial extent or range of population	L (1)	L (1)			
A.1.c. Increase or decrease in gaps or continuities between spawning areas	L (1)	L (1)			
B.1.a. Major life history strategies	M (0)	M (0)	Moderate Risk		
B.1.b. Phenotypic variation	M (0)	M (0)			
B.1.c. Genetic variation	L (1)	L (1)			
B.2.a. (1) Out-of-DPS spawners	L (1)	Low Risk (1)	Low Risk (1)		
B.2.a. (2) Out-of-MPG spawners	L (1)				
B.2.a. (3) Out-of-Population spawners	VL (2)				
B.2.a. (4) Within-population hatchery spawners	L (1)				
B.3.a. Distribution of population across habitat types	L (1)	L (1)	L (1)		
B.4.a. Selective change in natural processes or selective impacts	H (-1)	H (-1)	H (-1)		

Under Goal B, risk is elevated with respect to life history strategies and phenotypic variation, because of flow regulation, including the “flip-flop” water management strategy, affecting rearing conditions in the main stem below the Tieton River. Migration timing constraints in the lower Naches and the lower Yakima, and the aforementioned loss of rearing habitat in the lower Naches, both hamper mainstem rearing strategies and result in high risk with respect to the selective impacts metric.

The status relative to goal B could be improved by addressing phenotypic variation, beginning with a more detailed evaluation of spawning and rearing timing to evaluate the relative change in phenotypic characteristics for the population and the factors driving the shifts. If further analysis confirms a significant shift in phenotypic characteristics relative to the assumed historical condition or with comparable unaltered reference populations, restoration actions should be initiated. The status rating could also be improved by evaluating detrimental selective impacts of activities affecting within-basin passage, and reducing those impacts if warranted. Based on the ICTRT scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

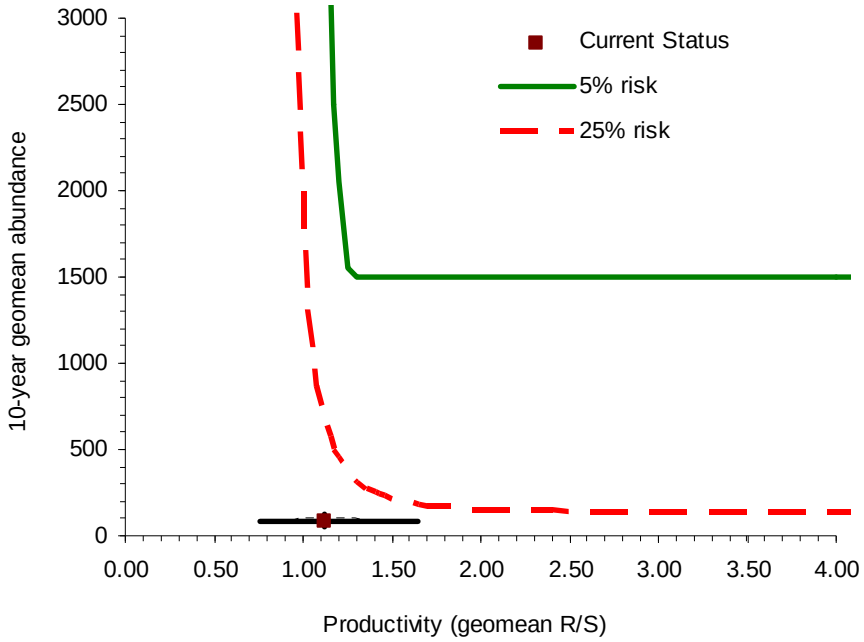
Overall, the Naches River steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate moderate risk. To achieve viable status, the abundance of the population must be increased sufficiently to maintain the population above the minimum threshold escapement of 1500 spawners. To achieve very low risk status (high viability) those improvements in abundance would need to be accompanied by the changes in spatial structure and diversity described above.

2.6.4 Upper Yakima Population

Abundance and Productivity

The ICTRT classified the Upper Yakima River steelhead population as “Large” in size based on historical habitat potential analysis (ICTRT 2007). This classification requires a minimum abundance threshold of 1500 wild spawners with sufficient productivity (greater than 1.26 returns per spawner at the abundance threshold) to avoid a 5% extinction risk on the ICTRT’s viability curve. With a 10-year (1996 to 2005) geomean abundance of 85 and a delimited/adjusted productivity value of 1.12 returns per spawner, the Upper Yakima River steelhead population is deemed to be at high risk of extinction, i.e., below the 25% risk line for a large-size population (Figure 2.15).

Figure 2.15: Upper Yakima abundance & productivity compared to viability curve



Curve is for a large-sized population. The point estimate includes a 1 standard error ellipse and 95% confidence intervals (1.81 x SE for both productivity and abundance estimates).

Spatial Structure and Diversity

Table 2.25 summarizes spatial structure and diversity risk assessment scores. The ICTRT placed the Upper Yakima River steelhead population at moderate risk for Goal A, which covers spatial structure factors, and high risk for Goal B, which covers genetic and phenotypic diversity. Using the lower score for the two goals gives the population an overall spatial structure and diversity risk rating of high.

Table 2.25: ICTRT spatial structure & diversity ratings for Upper Yakima population

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a Number and spatial arrangement of spawning areas	L (1)	L (1)	Moderate Risk (Mean = 0)	Moderate Risk	**High Risk**
A.l.b. Spatial extent or range of population	M (0)	M (0)			
A.1.c. Increase or decrease in gaps or continuities between spawning areas	H (-1)	H (-1)			
B.1.a. Major life history strategies	H (-1)	H (-1)	High Risk	High Risk	
B.1.b. Phenotypic variation	M (0)	M (0)			
B.1.c. Genetic variation	H (-1)	H (-1)			
B.2.a. (1) Out-of-DPS spawners	NA	Low Risk	Low Risk		
B.2.a. (2) Out-of-MPG spawners	NA				
B.2.a. (3) Out-of-Population spawners	NA				
B.2.a. (4) Within-population hatchery spawners	VL (2)				
B.3.a. Distribution of population across habitat types	L (1)	L (1)	L (1)		
B.4.a. Selective change in natural processes or selective impacts	H (-1)	H (-1)	H (-1)		

Under Goal A, extinction risk is elevated with respect to spatial extent or range and increase in gaps between spawning areas. Of the 14 MSAs, only seven are judged to have steelhead spawning in both their upper and lower portions (the ICTRT standard for occupancy). Another four MSAs are occupied in their lower portions only, and significant gaps exist between spawning areas.

Under Goal B, risk is elevated with respect to life history strategies and phenotypic variation, because of flow regulation, including the “flip-flop” water management strategy, affecting rearing conditions in the mainstem and because of curtailment of presmolt migration within and between tributaries. Migration timing constraints in the lower Yakima, long migration distances coupled with past and present constraints on passage at Roza Dam, and the aforementioned loss of rearing habitat in the mainstem both hamper mainstem rearing strategies and result in high risk with respect to the selective impacts metric.

Overall, the Upper Yakima River steelhead population is not considered viable under the ICTRT guidelines—both abundance/productivity and spatial structure/diversity elements indicate high risk of extinction. The ICTRT concludes that improving the overall rating to Viable will require substantial improvements in current abundance and productivity relative to the recent base period. Improved passage at Roza Dam and into Taneum and Big creeks was only recently restored (post 1988), and further improvements in survival and in habitat availability (including provision of access into currently blocked areas) will likely be required to meet overall abundance and productivity objectives for this population. Key improvements in spatial/structure and diversity (described above) will also be required.

3 Factors for Decline

3.1 Introduction	3.4 Relationship of Threats to Limiting Factors
3.2 Definition of Threats	3.5 In-Basin Threats and Limiting Factors
3.3 Definition of Limiting Factors	3.6 Out-of-Basin Threats and Limiting Factors

3.1 Introduction

This chapter gives an overview of the factors that have contributed to the decline in steelhead populations identified in Chapter 2. To provide a context for the actions presented in Chapter 5, this chapter discusses the threats and limiting factors currently affecting the four steelhead populations in the Yakima Basin. Chapter 3 does not give a reach-by-reach assessment of habitat conditions and limiting factors for Yakima Basin steelhead habitat. More detailed reach-specific assessments can be found in the habitat assessment portions of the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005) and the Limiting Factors Analysis conducted for the Washington State Conservation Commission (Haring 2001); numerous other watershed assessments give information for specific geographic areas. These more detailed assessments will be incorporated into the implementation scheduling process described in Chapter 6.

3.1.1 General Overview of Steelhead Population Decline

Salmon, and trout recolonized and expanded their range in the Columbia River Basin after the most recent Ice Age (10,000-15,000 years ago). Native Americans had access to an abundant fish resource comprised of coho, chum, and sockeye salmon, spring, summer, and fall runs of Chinook, steelhead, bull trout, cutthroat trout, Pacific lamprey, and white sturgeon. Their cultures were formed around the availability of anadromous fish (Craig and Hacker 1940), with catches increasing as their populations rose and fishing techniques developed. Estimates of pre-development (late 1700s) abundance of Columbia River salmon and steelhead ranged from about 8 million (Chapman 1986) to 14 million (NPPC 1986) fish.[27] While questions exist about the degree of cyclic variations in freshwater and ocean habitat conditions, it is quite certain that salmon and steelhead have declined to a small fraction of their former abundance and distribution (NRC 1996, Figure 3-2). In recent decades, the total run of all salmon and steelhead has ranged from one to two million fish, with about three-quarters of the recent spring Chinook and summer steelhead runs consisting of fish cultured to smolt size in hatcheries. The overall decline of anadromous fish runs in the Columbia Basin has been reviewed extensively (Busby et al. 1996; Lichatowich 1999; Nehlsen et al. 1991; NPPC 1986; NRC 1996).

[27] Estimates of pre-development salmon and steelhead numbers are based on multiplying the maximum catches in the latter part of the 1800s (which reached 3-4 million salmon and steelhead) with the assumed catch rates by all fishing gear.

The decline of salmon and steelhead in the Yakima Basin occurred in two major phases. During the first phase, between 1850 and roughly 1900, Yakima runs declined about 90% from historical values (Davidson 1953; Lichatowich 1999; Tuck 1995). Initial causes of decline include diversion of instream flows into unscreened watercourses for irrigation (Lichatowich 1999; Tuck 1995) and over-harvest in early mainstem fisheries. In the second phase, covering the years 1900 to the present, native sockeye (*O. nerka*), coho (*O. kisutch*), and summer Chinook were extirpated and the abundance of the other stocks fell to small fractions of historical values. The construction of dams to convert natural glacial lakes into storage reservoirs early in the twentieth century blocked off many miles of spawning and rearing habitat and, along with reduced flows and increased temperatures in the lower Yakima, led to the extinction of native sockeye salmon. Reservoir and diversion operations cut off access to headwater streams and significantly changed flow and temperature regimes downstream, resulting in reductions in spawning, rearing, and migratory habitat quality and quantity. Unscreened diversions are known to have stranded large numbers of fish. While a long history of fish screening programs has greatly reduced extent of such stranding, many unscreened diversions remain. Irrigation diversions reduced flows, sometimes to the point of drying out specific stream reaches. Irrigation drains have severely impacted water quality in some tributaries and in the lower Yakima River, (although recently many components of some irrigation effluents have been reduced).

Development of the Columbia River dams also had a large impact on anadromous fish runs by reducing survival rates for upstream and downstream migrants. Steelhead are able to return to the sea after spawning and then travel upstream to spawn again. The degree to which repeat spawners contributed to the productivity of Yakima Basin steelhead populations prior to European settlement is unknown, but is presumed depressed from historic levels due to general changes in habitat and the development and operation of the Columbia River hydropower system. Early hatcheries constructed to mitigate for fish loss at mainstem dams were operated without a clear understanding of population genetics. Although hatcheries were increasing the abundance of depleted stocks, they were probably also decreasing the diversity of the native populations with which they overlapped.

Human population growth and associated land uses within the basin (agriculture, mining, timber harvest, transportation systems, and urban and rural development) have significantly affected salmon and trout spawning and rearing habitat. The National Research Council Committee on Protection and Management of Pacific Northwest Anadromous Salmonids identified habitat problems as a primary cause of declines in wild salmon runs (ISAB 1996; ISAB 2000; NRC 1996). They identified the fragmentation and loss of available spawning and rearing habitat, migration delays, degradation of water quality, removal of riparian vegetation, decline of habitat complexity, alteration of stream flows and stream bank and channel morphology, alteration of ambient stream water temperatures, sedimentation, and loss of spawning gravel, pool habitat and large woody debris.

Floodplain development has degraded floodplain and channel function. Portions of the Yakima River and its tributaries have been detached from their historical floodplains, impairing floodplain function, reducing access to off-channel habitats, and reducing flow

and elevating temperatures. Urbanization (especially in alluvial floodplains) and livestock grazing practices have altered riparian habitat (Busby et al. 1996; NMFS 1996; Washington Department of Fisheries et al. 1993; West Coast Steelhead Biological Review Team 1999). Exotic species introductions have directly and indirectly affected steelhead. All these activities (harvest, hydropower, hatcheries, and habitat, both within and outside of the Yakima Basin) acted in concert to decrease the abundance, productivity, spatial structure, and diversity of steelhead populations in the Yakima Basin.

The 2004 Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005) and the Yakima River Habitat Limiting Factors Analysis for the Yakima (Haring 2001) describe, in some detail, the array of habitat modifications that currently affect the quantity and quality of salmonid habitat within the Yakima Basin. Although land and water management practices have typically improved in recent decades, factors such as storage dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and forest management all continue to affect steelhead and their habitat in the Yakima Basin.

3.1.2 Ongoing Efforts to Address the Decline of Steelhead

Changing land-use practices have reduced some threats to steelhead and increased others. Many activities that address threats and reverse the long-term decline of steelhead in the Yakima Basin have been initiated at the federal, state, and local levels (e.g., restrictive harvest regulations, habitat improvement projects, adoption of various land management rules, and development of conservation strategies and plans). Appendix C gives an overview of some of the major fish restoration programs in the Yakima Basin. While these efforts are important to the conservation and recovery of ESA-listed species, additional work is needed to minimize current threats to recovery. Chapter 5 proposes specific actions to be taken to recover steelhead populations. The remainder of Chapter 3 addresses the threats and limiting factors that currently affect steelhead populations in the Yakima Basin. This provides a context for understanding the purpose for actions proposed in Chapter 5.

3.2 Definition of Threats and Limiting Factors

3.2.1 Threats

Section 4(a) (1) of the Endangered Species Act of 1973 lists five sets of threats to consider when determining species status under the ESA. These listing factors are: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) over-utilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. Historical and current human activities associated with these five factors—especially habitat-related factors—have negatively affected steelhead in the Yakima Basin to the point that they were listed under the ESA, as described in Chapter 1. The National Marine Fisheries Service (1996) listed a number of habitat-related factors affecting the Middle Columbia River Steelhead

ESU and the Yakima Basin that led to the 1999 listing. They included water withdrawal, conveyance, and storage, flood control, logging, agriculture, mining, road building, and urbanization. Their list closely corresponds to the definition of threats used in this document.

The ESA describes the human and naturally induced actions that have resulted in the decline of steelhead populations as threats. According to NMFS' Draft Guidelines for Limiting Factors and Threats Assessment (2005):

> Threats are the human actions or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. Threats may be caused by the continuing results of past events and actions as well as by present and anticipated future events and actions.

While the term "threats" carries a negative connotation, it does not mean that activities identified as threats are inherently undesirable. They are typically legitimate and necessary human activities that may at times have unintended negative consequences on fish populations—and that can also be managed in a manner that minimizes or eliminates these negative impacts.

3.2.2 Limiting Factors

Limiting factors are the specific changes in conditions through which threats affect the abundance, productivity, spatial distribution, and diversity of the species of concern (NMFS 2005). Limiting factors are characterized in relation to the biological needs of the species. According to NMFS' Draft Guidelines for Limiting Factors and Threats Assessment (2005):

> Limiting factors are the physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish at the population, intermediate (e.g., stratum or major population grouping), or ESU-levels that result in reductions in VSP parameters (abundance, productivity, spatial structure, and diversity) at any life stage. Key limiting factors are those with the greatest impacts on a population's ability to reach its desired status.

Table 3.1, Table 3.2, Table 3.3, Table 3.4, Table 3.5 and Table 3.6 list the threats and associated limiting factors identified by recovery planners in the Yakima Basin. Sections 3.3.1 thru 3.3.6 describe these in more detail for each population area. NOAA Fisheries has identified 12 basic limiting factors that affect the viability of Middle Columbia Steelhead populations, as described below:

1) **Degraded floodplain connectivity and function:** The loss, impairment, or degradation of floodplain connectivity; access to previously available habitats (seasonal wetlands, off-channel habitat, side channels); and a connected and functional hyporheic zone.

2) **Degraded channel structure and complexity:** The loss, impairment, or degradation of channels; a suitable distribution of riffles and functional pools; functional amounts and sizes of large woody debris or other channel structure.

3) **Degraded riparian areas and LWD recruitment:** Factor includes loss, degradation or impairment of riparian conditions important for production of food organisms and organic material, shading, bank stabilizing by roots, nutrient and chemical mediation, control of surface erosion, and production of large-sized woody material.

4) **Altered hydrology:** Changes in the hydrograph that alter the natural pattern of flows over the seasons, causing inadequate flow, scouring flow, or other flow conditions that inhibit the development and survival of salmonids.

5) **Degraded water quality:** Degraded or impaired water quality due to abnormal temperature, or levels of suspended fine sediment, dissolved oxygen, nutrients, heavy metals, pesticides, herbicides and other contaminants (toxics).

6) **Altered sediment routing:** Altered sediment routing leading to an overabundance of fine-grained sediments, excess of course-grained sediments, inadequate course-grained sediments, and/or contaminated sediment.

7) **Impaired fish passage:** The total or partial human-caused blockage to previously accessible habitat that eliminates or decreases migration ability or alters the range of conditions under which migration is possible. This may include seasonal or periodic total migration blockage.

8) **Hatchery-related adverse effects:** Any hatchery-related adverse effects on natural-origin salmonid population survival and productivity.

9) **Harvest-related adverse effects:** Any harvest-related adverse effects on survival.

10) **Predation/Competition/Disease:** Predation or competition levels that have been elevated above likely rates in a normative system due to human actions.

11) **Degraded estuarine and nearshore marine habitat:** The loss, impairment or degradation of intertidal, salt marsh, and other functional estuarine and marine vegetation; altered amounts, quality, distribution, and timing of freshwater inflows; loss of estuary complexity; access to previously available habitats; and inadequate large woody debris.

12) **Mainstem Columbia River hydropower-related adverse effects:** Any adverse effects caused by the operation of hydroelectric dams in the mainstem Columbia and Snake rivers.

Table 3.1, Table 3.2, Table 3.3, Table 3.4, Table 3.5 and Table 3.6 show the correspondence between the limiting factors used in this plan and these more general limiting factors from NOAA Fisheries. For more details on NOAA Fisheries' limiting factors and their application to the Middle Columbia River Steelhead DPS, see the Middle Columbia Steelhead Recovery Plan (to be released in 2009).

Table 3.1: Basinwide threats and limiting factors

Basinwide Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Regulation of stream flow for irrigation storage and flood control	1	Inadequate migration flow because of irrigation storage or flood control headspace targets	Flow	4) Altered hydrology	BW1,3,4,5
	2	Altered hydrograph affects riparian and submerged vegetation	Flow	4) Altered hydrology 3) Degraded riparian area & LWD recruitment	BW1,3,4, 5,12
Water storage and diversion structures	3	Entrainment, injury or delay of downstream migrants at diversions	Withdrawals (entrainment), Obstructions	7) Impaired fish passage	BW2,6
Forest harvest practices, road construction and fire suppression	4	Increased risk and severity of forest disease, pests and land-scape scale fire	Sediment load, Flow	4) Altered hydrology 6) Altered sediment routing	BW13
Climate variation and trends	5	Drought worsens effects of other threats on adult spawning success and juvenile survival	Flow, Temperature, Key habitat quantity	4) Altered hydrology 5) Degraded water quality	
In-basin Harvest	6	Incidental take in legal fisheries	Harassment	9) Harvest-related adverse effects	BW14
	7	Illegal harvest of steelhead	Harassment	9) Harvest-related adverse effects	BW14

Basinwide Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Ecological Legacy	8	Slow recolonization of reopened habitats by small populations	NONE	NONE	BW6,7
	9	Lack of nutrients in rearing areas	Food	5) Degraded water quality	BW8,15
	10	Reduction of beaver activity	Channel stability, Flow	4) Altered hydrology 2) Degraded channel structure & complexity	BW11

Table 3.2: Lower mainstem Yakima threats and limiting factors

Lower Mainstem Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limited Factors**	**Actions**
Withdrawal of stream flow for irrigation and hydropower	1	Inadequate migration flow below diversions	Flow	Altered hydrology	LM2,5,7
	2	Loss of habitat quantity and diversity below diversions	Flow	Altered hydrology	LM2,5,7
	3	Increased summer water temperature below diversions	Temperature	Degraded water quality	LM7
Conveyance of irrigation deliveries and return flow in streams	4	High temperature, sediment and other pollutants in summer flow	Temperature, Sediment load, Chemicals	Degraded water quality Altered sediment routing	LM2,9
	5	False attraction due to high flow and/or mixing of sources	Flow	Altered hydrology	LM2,9
Water storage and diversion structures	6	Entrainment, injury or delay of downstream migrants at diversions	Withdrawals (entrainment), Obstructions	Impaired fish passage	LM3
Floodplain constriction and development	7	High water temperature, low flow in summer due to floodplain storage loss	Temperature, Flow	Altered hydrology Degraded water quality	LM7
	8	Degraded riparian vegetation needed for shade, bank stability and food	Habitat diversity	Degraded riparian area & LWD recruitment	LM6,7

Lower Mainstem Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limited Factors**	**Actions**
	9	Reduced availability of woody debris in the channel and floodplain	Key habitat quantity	Degraded riparian area & LWD recruitment	LM6,7
	10	Simplified, degraded, and/or unstable stream channels	Channel stability, Key habitat quantity	Degraded channel structure & complexity	LM6
	11	Reduced quantity and/or quality of side channel habitat	Habitat diversity, Key habitat quantity	Degraded floodplain connectivity & function	LM6,7
Management of Gravel Pits	12	Increased habitat for predatory and exotic fish	Predation, Competition (with other species)	Predation/Competition/Disease	BW10
	13	River capture creating channel instability and raising water temperature	Channel stability, Temperature	Degraded channel structure & complexity Degraded water quality Altered sediment routing	BW10
Non-native fish species	14	Predation by bass and catfish	Predation	Predation/Competition/Disease	LM3,7, BW16
Native predatory fish species	15	Increased predation by northern pikeminnow	Predation	Predation/Competition/Disease	LM3,7, BW16
Predatory birds and mammals	16	Increased predation by gulls and pelicans, especially at inriver structures	Predation	Predation/Competition/Disease	LM3,7

Table 3.3: Satus population area threats and limiting factors

Satus Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Conveyance of irrigation deliveries and return flow in streams	1	High temperature, sediment and other pollutants in summer flow	Temperature, Sediment load, Chemicals	Degraded water quality Altered sediment routing	S3,4
Water storage and diversion structures	2	Upstream migration blockages or delays at diversions	Obstructions	Impaired fish passage	S5
Floodplain constriction and development	3	High water temperature, low flow in summer due to floodplain storage loss	Temperature, Flow	Altered hydrology Degraded water quality	S1
	4	Simplified, degraded, and/or unstable stream channels	Channel stability, Key habitat quantity	Degraded channel structure & complexity	S1
	5	Reduced quantity and/or quality of side channel habitat	Habitat diversity, Key habitat quantity	Degraded floodplain connectivity & function	S1
Forest harvest practices, road construction and fire suppression	6	Impassable and/or unstable stream crossings	Obstructions, Channel stability	Impaired fish passage Degraded channel structure & complexity	S6

Satus Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	7	Loss of riparian, floodplain and wetland function due to tree harvest and road building	Habitat diversity, Flow	Altered hydrology Degraded riparian area & LWD recruitment	S7
	8	Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage	Sediment load, Temperature	Altered sediment routing Degraded water quality	S7
Grazing Impacts	9	Damage to stream channels, banks and riparian zones	Channel stability, Habitat diversity	Degraded channel structure & complexity Degraded riparian area & LWD recruitment	S2
	10	Sedimentation of streams	Sediment load	Altered sediment routing	S2
	11	High water temperature, low flow in summer due to wet meadow storage loss	Temperature, Flow	Altered hydrology Degraded water quality	S8

Table 3.4: Toppenish population area threats and limiting factors

Toppenish Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Withdrawal of stream flow for irrigation and hydropower	1	Loss of habitat quantity and diversity below diversions	Flow	Altered hydrology	T5
	2	Increased summer water temperature below diversions	Temperature	Degraded water quality	T5
Conveyance of irrigation deliveries and return flow in streams	3	High temperature, sediment and other pollutants in summer flow	Temperature, Sediment load, Chemicals	Degraded water quality Altered sediment routing	T2,6
	4	False attraction due to high flow and/or mixing of sources	Flow	Altered hydrology	T6
	5	Stream channel modifications to convey irrigation or return flow	Channel stability, Habitat diversity, Key habitat quantity	Degraded channel structure & complexity	T1,6
Water storage and diversion structures	6	Entrainment, injury or delay of downstream migrants at diversions	Withdrawals (entrainment), Obstructions	Impaired fish passage	T4
Floodplain constriction and development	7	High water temperature, low flow in summer due to floodplain storage loss	Temperature, Flow	Altered hydrology Degraded water quality	T1,2
	8	Degraded riparian vegetation needed for shade, bank stability and food	Habitat diversity	Degraded riparian area & LWD recruitment	T7

Toppenish Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	9	Reduced availability of woody debris in the channel and floodplain	Key habitat quantity	Degraded riparian area & LWD recruitment	T1
	10	Simplified, degraded, and/or unstable stream channels	Channel stability, Key habitat quantity	Degraded channel structure & complexity	T1
	11	Reduced quantity and/or quality of side channel habitat	Habitat diversity, Key habitat quantity	Degraded floodplain connectivity & function	T1
Forest harvest practices, road construction and fire suppression	12	Impassable and/or unstable stream crossings	Obstructions, Channel stability	Impaired fish passage Degraded channel structure & complexity	T3,4
	13	Loss of riparian, floodplain and wetland function due to tree harvest and road building	Habitat diversity, Flow	Degraded riparian area & LWD recruitment Degraded floodplain connectivity & function	T8
	14	Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage	Sediment load, Temperature	Degraded water quality Altered sediment routing	T8
Livestock grazing	15	Damage to stream channels, banks and riparian zones	Channel stability, Habitat diversity	Degraded channel structure & complexity Degraded riparian area & LWD recruitment	T10

Toppenish Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	16	Sedimentation of streams	Sediment load	Altered sediment routing	T9
	17	High water temperature, low flow in summer due to wet meadow storage loss	Temperature, Flow	Altered hydrology Degraded water quality	T10
	18	Stock water diversions during low stream flow periods	Flow, Temperature	Altered hydrology Degraded water quality	T5

Table 3.5: Naches population area threats and limiting factors

Naches Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Regulation of stream flow for irrigation storage and flood control	1	Inadequate migration flow below reservoirs because of irrigation storage or flood control headspace targets	Flow	Altered hydrology	N30, BW1
	2	Low June-August and high Sept-Oct flows below reservoirs	Flow	Altered hydrology	N4
Withdrawal of stream flow for irrigation and hydropower	3	Loss of habitat quantity and diversity below diversions	Flow	Altered hydrology	N1,2,3,4,15,17,21,24,25,26, BW5
	4	Increased summer water temperature below diversions	Temperature	Degraded water quality	N1,2,3,4,15,17,21,24,25,26, BW5
Conveyance of irrigation deliveries and return flow in streams	5	Stream channel modifications to convey irrigation or return flow	Channel stability, Habitat diversity, Key habitat quantity	Degraded channel structure & complexity	
Water storage and diversion structures	6	Migration blockages at storage dams	Obstructions	Impaired fish passage	N9
	7	Upstream migration blockages or delays at diversions	Obstructions	Impaired fish passage	N16

Naches Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	8	Coarse sediment deficiency below storage dams	Key habitat quantity	Altered sediment routing	
Floodplain constriction and development	9	High water temperature, low flow in summer due to floodplain storage loss	Temperature, Flow	Altered hydrology Degraded water quality	N5,10,11,12, 19,20,28
	10	Simplified, degraded, and/or unstable stream channels	Channel stability, Key habitat quantity	Degraded channel structure & complexity	N10,11,12,14, 20,27,28
	11	Reduced quantity and/or quality of side channel habitat	Habitat diversity, Key habitat quantity	Degraded floodplain connectivity & function	N5,10,11,12, 19,20, 27,28
	12	Channel aggradation upstream from constrictions	Obstructions	Impaired fish passage	N6,18,20
	13	Impassable and/or unstable stream crossings	Obstructions, Channel stability	Impaired fish passage Degraded channel structure & complexity	

Naches Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Forest harvest practices, road construction and fire suppression	14	Loss of riparian, floodplain and wetland function due to tree harvest and road building	Habitat diversity, Flow	Degraded riparian area & LWD recruitment Degraded floodplain connectivity & function	N7,8,14,22,23
	15	Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage	Sediment load, Temperature	Altered sediment routing Degraded water quality	N8
	16	Loss of forest cover needed to moderate snowmelt	Flow	Altered hydrology	BW10,13
	17	Increased risk and severity of forest disease, pests and landscape-scale fire	Sediment load, Flow	Altered hydrology Altered sediment routing	N23, BW10,13
Livestock grazing	18	Damage to stream channels, banks and riparian zones	Channel stability, Habitat diversity	Degraded channel structure & complexity Degraded riparian area & LWD recruitment	N22,29

Naches Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	19	Sedimentation of streams	Sediment load	Altered sediment routing	N22,29
Streamside recreation	20	Damage to stream channels, banks and riparian zones	Channel stability, Habitat diversity	Degraded channel structure & complexity Degraded riparian area & LWD recruitment	N13
	21	Disturbance of spawning fish and redds	Harassment	NONE	N13
"Ecological Legacy"	22	Slow recolonization of reopened habitats by small populations		NONE	BW7

Table 3.6: Upper Yakima population area threats and limiting factors

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Regulation of stream flow for irrigation storage and flood control	1	High June-August flow below reservoirs	Flow	Altered hydrology	U3
	2	Unstable and/or low Winter-Spring flows below diversions	Flow	Altered hydrology	U21
Withdrawal of stream flow for irrigation and hydropower	3	Inadequate migration flow below diversions	Flow	Altered hydrology	U2
	4	Loss of habitat quantity and diversity below diversions	Flow	Altered hydrology	U4
	5	Increased summer water temperature below diversions	Temperature	Degraded water quality	U4,5,BW5
Conveyance of irrigation deliveries and	6	High summer flow in delivery reaches	Flow	Altered hydrology	U3,11

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
return flow in streams	7	High temperature, sediment and other pollutants in summer flow	Temperature, Sediment load, Chemicals	Degraded water quality Altered sediment routing	U19
Water storage and diversion structures	8	Migration blockages at storage dams	Obstructions	Impaired fish passage	U8
	9	Upstream migration blockages or delays at diversions	Obstructions	Impaired fish passage	U1,5,6,7,9
Floodplain constriction and development	10	High water temperature, low flow in summer due to floodplain storage loss	Temperature, Flow	Altered hydrology Degraded water quality	U12,14,15
	11	Degraded riparian vegetation needed for shade, bank stability and food	Habitat diversity	Degraded riparian area & LWD recruitment	U15

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	12	Reduced availability of woody debris in the channel and floodplain	Key habitat quantity	Degraded riparian area & LWD recruitment	U13,14
	13	Simplified, degraded, and/or unstable stream channels	Channel stability, Key habitat quantity	Degraded channel structure & complexity	U11,12,13, 14,15
	14	Reduced quantity and/or quality of side channel habitat	Habitat diversity, Key habitat quantity	Degraded floodplain connectivity & function	U12,13,15
	15	Impassable and/or unstable stream crossings	Obstructions, Channel stability	Impaired fish passage Degraded channel structure & complexity	

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Watershed Development	16	Changes in timing and amount of stream flows due to altered upland runoff patterns (locally variable effects due to impervious areas, irrigation return flows etc.)	Flow, Temperature	Altered hydrology Degraded water quality	U15,16,17 BW10
	17	Stormwater runoff and associated water quality degradation	Sediment load, Chemicals	Degraded water quality Altered sediment routing	U16,17,19,BW10
Management of Gravel Pits	18	Increased habitat for predatory and exotic fish	Predation, Competition (with other species)	Predation/Competition/Disease	BW10
	19	River capture creating channel instability and raising water temperature	Channel stability, Temperature	Degraded channel structure & complexity Degraded water quality	U13, BW10

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Forest harvest practices, road construction and fire suppression	20	Impassable and/or unstable stream crossings	Obstructions, Channel stability	Impaired fish passage Degraded channel structure & complexity	U10
	21	Loss of riparian, floodplain and wetland function due to tree harvest and road building	Habitat diversity, Flow	Degraded riparian area & LWD recruitment Degraded floodplain connectivity & function	U13,18 BW10
	22	Acceleration and degradation of runoff (sediment, high summer temperature) by road and skid trail drainage	Sediment load, Temperature	Altered hydrology Degraded water quality	U18, BW10
	23	Loss of forest cover needed to moderate snowmelt	Flow, Temperature	Altered hydrology Degraded water quality	U18, BW10,13

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
Livestock grazing	24	Damage to stream channels, banks and riparian zones	Channel stability, Habitat diversity	Degraded channel structure & complexity Degraded riparian area & LWD recruitment	U14
	25	Sedimentation of streams	Sediment load Temperature	Altered sediment routing Degraded channel structure & complexity	
	26	High water temperature, low flow in summer due to wet meadow storage loss	Temperature, Flow	Altered hydrology Degraded water quality	U20
	27	Stock water diversions during low stream flow periods	Flow, Temperature	Altered hydrology Degraded water quality	
Streamside Recreation	28	Damage to stream channels, banks and riparian zones	Channel stability, Habitat diversity	Degraded channel structure & complexity Degraded riparian area & LWD recruitment	
	29	Disturbance of spawning fish and redds	Harassment	NONE	

Upper Yakima Threats and Limiting Factors					
Threat	**#**	**Limiting Factor**	**Level 3 EDT Survival Factors**	**NOAA Limiting Factors**	**Actions**
	30	Blockage of fish migration	Obstructions	Impaired fish passage	
"Ecological Legacy"	31	Slow recolonization of reopened habitats by small populations	NONE	NONE	BW7

3.2.3 Relationships of Threats to Limiting Factors

The relationship between threats and limiting factors can be complex, with a single threat affecting many limiting factors, and a single limiting factor being a function of many interacting threats. Sections 3.5.1 to 3.5.6 describe the interaction of threats and limiting factors that affect the basin as a whole, the shared migration corridor of the lower mainstem and the four population areas. Section 3.6 gives a brief overview of threats and limiting factors acting on Yakima Basin steelhead during their time outside of the Yakima Basin.

3.3 In-Basin Threats and Limiting Factors

The following sections describe the threats and limiting factors that occur throughout the basin, in the Lower Yakima River, and in the four population areas—Satus Creek, Toppenish Creek, Naches River and Upper Yakima.

3.3.1 Basinwide Threats and Limiting Factors

See Table 3.1. for a compilation of basinwide threats and limiting factors, which are also linked to the recovery actions described in Chapter 5, Recovery Actions.

Basinwide Effects of Changed Flow Regimes

In the Yakima Basin, water is an essential resource. Since the 1850s, extensive water supply systems have been developed to store and deliver water to irrigated agriculture and, to a lesser degree, to industrial, domestic, and hydropower users. This has made the Yakima Basin one of the most productive agricultural regions in the United States and the world. The federal government authorized the Yakima Irrigation Project in 1905. This brought a number of private irrigation projects under the jurisdiction of the BOR and resulted in construction of five storage reservoirs that enabled expansion of irrigated acreage to 464,000 acres in six divisions. Lands irrigated under the Project extend from Cle Elum to the Tri-Cities. There are six major diversion dams (Easton, Roza, Tieton, Wapato, Sunnyside, and Prosser), 420 miles of canals, 1,697 miles of laterals, 30 pumping plants, and 144 miles of drains. Generators served by Roza and Chandler canals produce hydroelectric power ((BOR 2002), and a generator was installed at Tieton Dam in 2006. The Wapato Irrigation Project diverts its water from the river just below Union Gap to serve 136,000 acres of irrigated lands on the Yakama Reservation. Water delivery and storage systems in the basin range from these larger systems to small ditches on tributaries owned and managed by one or two private landowners. Many tributaries have been converted into irrigation distribution systems, such as the Wilson/Naneum Creek system in the Kittitas Valley, or drainage systems such as lower Toppenish Creek and Marion Drain.

These diverse systems are an essential part of the basin’s economy, past, and present. They have also had significant impacts on fish populations in the basin. Managing water supply and delivery systems in a manner that meets economic needs while minimizing negative impacts on fish populations is one of the principal challenges faced in

recovering steelhead populations. There have been many efforts to lessen the impact of this infrastructure on fish—improved screening, improvements in water use efficiency, reconstruction for improved or restored passage—but the infrastructure itself has remained in place and expanded over time. Additional changes in the configuration of infrastructure—the function and location of storage dams, delivery and return points for irrigation water conveyance, delivery, and routing of water—are required to address the impacts of the altered flow regimes (see Chapter 5).

Adequate flows are necessary for migrating adult steelhead to pass upstream to spawning areas, provide rearing habitat, and facilitate smolt emigration to marine environments. Flows also affect other habitat parameters like temperature, riparian vegetation, and food supply. In an unregulated condition, the flows in the Yakima Basin would be dominated by snowmelt-driven discharge peaks in May or June that then decline to ground-water driven base flows in August and September. Late autumn rainfall and minor snowmelt would augment summer base flow, with Chinook winds causing occasional winter high water events. Steelhead are adapted to these natural seasonal flow patterns, which maintained a variety of habitats and facilitated migratory behavior.

Management of water storage and delivery systems in the Yakima Basin has significantly altered this flow pattern. Now winter and spring runoff from the upper Yakima, Kachess, Cle Elum, Tieton and Bumping rivers is captured in storage reservoirs and is utilized to meet summer irrigation needs in accordance with yearly entitlements. These operations result in streamflows across the basin that are often out of phase with the life-history requirements of native salmonids (Fast et al. 1991; Stanford et al. 2002) and riparian species such as cottonwoods (Jamieson and Braatne 2001). The most significant changes in flow regimes are the creation of: 1) unnaturally low flows, 2) unnaturally high flows, 3) rapidly changing flow levels, 4) return flows, and 5) altered sediment and wood transport. Issues associated with each of these are described below. The most significant area in which a largely natural flow regime has been maintained is the Naches River above its confluence with the Tieton.

Reduced Flows

Low flows arise under two basic situations. From April through October, irrigation diversions and other water withdrawals reduce streamflows in tributaries throughout the basin (examples include Manastash, Ahtanum, and Cowiche creeks and the Teanaway River), in the lower mainstem Naches, and in the mainstem Yakima below Sunnyside Dam.[28] These low flows and associated increased temperatures limit the availability of summer and early fall rearing habitat in affected tributary and lower mainstem reaches and create passage barriers for migrating and rearing steelhead. As discussed in section 2.5.1.1, the timing of the start of upstream migration into the Yakima River by adult steelhead is driven by flow and temperature conditions. Decreased flows and increased temperatures generally prevent adults from entering the Yakima River prior to September. Since fish are holding in either the Columbia or Yakima rivers from mid-

[28] Winter diversions for power generation and, in some tributaries, for stock water, can also decrease stream flows. These instances are addressed in the area-specific discussions.

summer until spawning begins in late winter, the effect that this delay in in-migration has on survival and reproductive success is unknown.

Low flows also occur in the Tieton River below Tieton dam and the Upper Yakima and Cle Elum rivers when releases from Cle Elum, Kachess, and Keechelus dams are minimized to store water for irrigation. The effects of these low winter and spring flows on rearing juveniles are not well understood. Lowered flows also occur in the bypass reaches associated with the Roza and Chandler Hydro power plants.

These low flows and associated increases in water temperature are hypothesized to increase travel times for migrating smolts, expose smolts to increased predation rates, and reduce the extent and variety of off-channel habitat available for use during the out-migration period. In many years, these low flows truncate the out-migration window for smolts migrating downstream and may alter the emigration cues that trigger smolts to emigrate towards the ocean. It is also likely that reduced streamflow and longer travel time in the lower Yakima River decrease survival of kelts during their downstream migration. The need for a better understanding of the relationship between flows, temperature and other habitat conditions and survival of outmigrating smolts is highlighted in Chapter 7.

Overall, decreased flows and associated temperature regimes have a selective effect on Yakima Basin steelhead for both in-migration (delaying entry to the system) and out-migration (truncating the smolt run and kelt out-migration in late spring). EDT model results based on spawn timing and flow in the tributaries show that these effects probably are most severe on the Naches and Upper Yakima populations. The potential for viable steelhead life histories that included both short- and long-term juvenile rearing in mainstem habitats has been reduced by the loss of summer rearing habitat extent (low flow) and suitability (temperature) in the lower Naches River and the Yakima River below Sunnyside diversion dams.

Increased Flows

The mainstem Yakima, Cle Elum, Tieton, and lower Naches rivers are all used to deliver water stored in large headwater reservoirs to downstream users. This results in unseasonably high flows (Bumping Reservoir has a much more limited effect on the Bumping and Naches rivers due to its small size). Flows are increased further due to the “flip-flop” flow management strategy, which was established in 1981 in response to a suit brought against BOR by the Yakama Nation in order to protect spring Chinook redds in the Upper Yakima and Cle Elum rivers. Flip-flop consists of delivering water primarily via the Upper Yakima in the spring and summer while conserving water in Rimrock reservoir for use in August through October, when flows in the Upper Yakima are dropped to the levels that will be sustained through the winter in order to protect redds.

Water deliveries in general and flip-flop operations in particular result in high summer flow through the Cle Elum/Yakima arm until September when the water supply is switched to the Rimrock and Bumping reservoirs in the Tieton/Naches arm, which then experiences high flow until the irrigation season ends in October. While flip-flop has helped to protect upper Yakima spring Chinook, associated high flows have significantly impacted steelhead habitat. The most drastic impacts are in the Tieton River, where the

unnaturally high and sustained flows in late summer and fall are posited to have greatly reduced available habitat for rearing steelhead, both through the immediate influence of high velocities and the reduction in mid-to small sized sediment and woody debris (currently Oak Creek, a small tributary with unregulated flows, is the only part of the Tieton River watershed consistently used by spawning steelhead).

Fry emergence in the Upper Yakima occurs from mid-June through the end of July, when natural flows would begin to drop. The sustained high flows associated with irrigation water deliveries are hypothesized to reduce growth and potentially survival. Pearsons et al. (1993) studied at *O. mykiss* in regulated reaches of the Yakima Basin and hypothesized that such flow fluctuations during the month following swim-up were responsible for the scarcity of young-of-the-year observed during subsequent snorkeling and electro-fishing surveys in areas with highest redd densities. They also found that *O. mykiss* in the Yakima River grow slower than trout in other regional rivers, and attributed these slow growth rates to degraded growing conditions produced by reservoir releases throughout the summer rearing period. Flow manipulation may also affect steelhead through competition for food, which becomes scarcer under fluctuating or artificially high flows (James et al. 1999). The increases in summer flows and associated decreases in summer temperatures in the Upper Yakima are hypothesized to favor resident life histories in the mainstem, potentially reducing the number of anadromous smolts produced. Chapter 7 identifies better understanding the impacts of delivery flows and flip-flop on juvenile steelhead as a key knowledge gap.

In tributary settings, high flows associated with use for irrigation conveyance and operation spill from canals can have mixed effects on habitat conditions. This is primarily an issue in the lower reaches of tributaries to the Upper Yakima, which are used to convey irrigation delivery and return flows.

Rapid Changes in Flow

Flow oscillations during the irrigation season may also reduce habitat quality for juvenile steelhead. While a seasonal range of flows is vital, stable base flows support high salmonid growth rates during periods of high ecosystem production from late spring through early fall (Poff and Ward 1989; Stanford et al. 1996). Rapid reductions in flow associated with flip-flop operations in the Upper Yakima and Naches and the initiation of storage control below Parker can reduce macroinvertebrate populations that serve as food source (Arango 2001), and limit growth of riparian vegetation, especially cottonwood seedlings. Power plant operation and screen maintenance activities in the Chandler and Roza canals can also combine to produce large flow fluctuations in the Yakima River when the canals are dropped for maintenance and rewatered to generate power.

Return Flows

Return flows associated with irrigation use can increase stream temperatures and transport sediment and associated contaminants into natural waterways. Return flows can also create false attraction when water diverted upstream is released well downstream and attracts returning adults that gravitate towards the characteristics of the upper basin water

source. Note that subsurface return flows can also reduce water temperatures and provide habitat benefits. Specific return flow issues are addressed in subsequent sections.

Affects of Altered Flows on Sediment and Wood Transport

River systems naturally transport large amounts of sediment downstream. The continuous removal and deposition of sediment plays a key role in the formation of complex floodplains and associated fish habitat. These changes also affect fish through the availability of appropriately sized spawning gravels and the productivity of macro-invertebrate populations and other prey species. Both instream structures and changed flow regimes associated with water delivery and use can change sediment transport.

Large dams may prevent movement of sediment, resulting in reduced availability of sediment downstream. Smaller diversion dams and other instream structures can dramatically change sediment dynamics in upstream and downstream reaches. Changes in flow regimes change the ability of stream systems to transport and deposit sediments. Reaches regularly exposed to artificially high flows may show scouring, loss of spawning gravels, channel simplification, and loss of habitat diversity; inversely, areas with reduced flows may show increased deposition of fine sediments.

Dams, diversions, other structures, and changes in flow regimes can also significantly change the distribution of large woody debris in a river system by blocking its downstream movement in some areas and by washing it out of other areas. Woody debris has also frequently been removed as part of system operations and maintenance.

Flow-induced Changes in Vegetation

Altered flow regimes in most mainstem reaches are incompatible with the flow characteristics required for black cottonwood to successfully regenerate from seed (Jamieson and Braatne 2001). Cottonwood is dependent on a gradual reduction in the spring snowmelt runoff and on exposed sediments on gravel bars for seed establishment. Too rapid a drop in spring flows exceeds new seedlings' root growth ability, resulting in loss of root contact with the local water table and seedling death. Constant of increasing streamflow from spring into summer (as occurs in the Upper Yakima) limits the exposure of suitable substrates. High streamflow during the fall months (as occurs in the Tieton and lower Naches rivers) scours and "drowns" newly established seedlings. The effects are most notable in the Naches and Wapato reaches, where the number of exposed gravel bars and the channel width/depth ratio has increased over time. In the Upper Yakima, higher flows allow replacement of cottonwood stands by other shrub and grass dominated riparian vegetation (typically dominated by Russian olive, Pacific willow, reed canary grass, or European silver willow). It is currently unknown how the loss of cottonwood recruitment will affect steelhead. Cottonwood is a keystone species to interior Columbia riparian zones. Loss of this species will affect shade, large wood input, temperature, width/depth ratios, availability of riparian prey items for salmonids, and other ecosystem scale effects. Natural high spring flows may also play a role in limiting the extent of aquatic vegetation in the lower mainstem Yakima River.

Unscreened Diversions

Diversion structures and other water delivery infrastructure and practices (such as running irrigation ditches across natural streams) can also funnel fish into water delivery systems that are not managed as fish habitat. This can result in significant mortality when fish enter pumped systems or are stranded in irrigation ditches. It may also cause delay and injury for fish that are able to return to natural stream systems. Screening of diversions has been a priority in the Yakima Basin since the 1920s, when some of the first self-cleaning fish screen designs were developed in the basin. Many diversions, especially larger ones, have had effective fish screens installed, but there are also still many unscreened diversions in the basin.

Floodplain Development

The floodplain reaches of the Naches and Yakima rivers once consisted of complex networks of braided channels covered by dense riparian forests. In many areas, river channels have been leveed, armored, realigned, and shortened, severely diminishing natural river-floodplain interactions. Floodplains have always been favored sites for agricultural fields, industrial areas, residential and commercial structures, railways and roads, and extensive systems of dikes and drains have been built to protect these areas. Overall, floodplain development has resulted in profound alterations in fish habitat in the Yakima Basin, including:

- Reduced connectivity between streams and adjacent riparian areas, floodplains, and uplands
- Elevated fine sediment yields and water temperatures
- Reduced large woody debris to trap sediment, stabilize banks and form pools
- Reduced vegetative canopy to minimize solar heating of streams and provide bank stability and food
- Modified streams channels with reducing rearing habitat and increasing water temperature fluctuations
- Altered peak flow volume and timing, leading to channel changes and potentially altering fish migration behavior
- Altered floodplain function, water tables, and base flows
- Reduced flows in summer due to floodplain storage loss

For more general background on the impacts of floodplain development, see Henjum et al. (1994), McIntosh et al. (1994), Rhodes et al. (1994), Wissmar et al. (1994), National Research Council (1996), Spence et al. (1996), and Lee et al. (Lee et al. 1997). The best references on floodplain conditions on the Yakima are Snyder and Stanford (2001), Sanford et al. (2002), and Eitemiller et al. (2002).

Gravel Mines

Floodplain gravel mining has had significant impacts on floodplains throughout the basin, including along I-90 in Kittitas County, near the cities of Yakima and Selah and in the Wapato reach downstream. Dikes associated with gravel mines constrict the floodplain, and when they burst, gravel pits can cause avulsion of the river channel and act as sediment sinks that increase stream power and erosion downstream. Ponds in abandoned gravel pits can warm adjacent river temperatures and act as reservoirs for bass, catfish and other potential introduced species that prey on and/or compete with steelhead. Management of past, current and future gravel pit operations should strive to minimize these impacts (Yakima River Floodplain Mining Impact Study Team 2004).

Upland Watershed Development

While the effect of floodplain development on fish habitat is generally far more dramatic, upland development for commercial, residential, and agricultural use can also impact steelhead habitat. Increases in impervious area associated with buildings and pavement, reductions in vegetative cover, and the presence of roads, drainage ditches and storm water systems all facilitate rapid drainage of surface water, increasing streamflows and sediment inputs immediately after precipitation events, and reducing groundwater recharge and associated base flows in streams. Both overland flows and contamination of groundwater can result in transport of pollutants from upland areas to stream systems. Development pressure in the Yakima Basin is focused in the Naches and Upper Yakima population areas, in the greater Yakima area and in the corridor from Easton to Ellensburg.

Population Growth and Associated Development

While many of the impacts to fish habitat addressed in this plan are a function of past land use patterns, it must also address future development impacts. Human population growth in the Yakima Basin will continue, both from relatively high birth rates in the valley, and immigration into the valley. A review of the Comprehensive Plan Land Use maps of communities within the basin clearly indicate that whether urban or rural, the bulk of land use and development for future population growth will occur along the Yakima River main-stem and major tributary corridors where there is water, an existing core of rail and road transportation infrastructure, major concentrations of urban services, and high value shoreline property. Additionally, large numbers of eastern Washington residents recreate along the basin waterways. Population growth may increase camping, hiking, fishing, and off-road-vehicle activities, especially on the publicly owned lands of the upper watersheds. Numerous programs within local government, land use planning, and development regulations are designed to manage the impacts of population growth; applying these in a balanced manner that protects steelhead habitat while supporting economic growth and private property rights will require a strong commitment from local governments, landowners and the public at large.

Increased Forest Disease, Pests, and Landscape-scale Fire

The health and stability of many forest stands in the basin are declining, especially in the managed forests at lower and middle elevations on the Yakama Reservation, on state and

private lands, and on USFS lands in the Naches, Swauk, Teanaway, and Cle Elum drainages. A legacy of fire suppression has increased the density of less fire- and pest-resistant tree species, and consequently catastrophic fire or pest outbreaks are increasingly likely to occur. While periodic, low-level disturbance contributes to overall forest health, landscape-scale fires would likely result in increased peak flows, lower summer flows, and increased sediment delivery for several decades, increasing the risk of extinction for steelhead. The relationship between wildland fire to aquatic ecosystems is reviewed by Dunham et al. (2003) and Riemann et al. (2003) Current low funding levels for efforts to improve forest health suggest that the risk may continue to increase.

Forestry Practices

Habitat conditions in the forested areas of the basin are generally better than in lowlands, but past forest harvest practices, road construction and maintenance, and fire suppression have all had impacts of steelhead habitat. These activities can lead to road encroachment on streams and floodplains, riparian damage, impassable and/or unstable stream crossings, acceleration of runoff, increased landslides and sediment loading, elevated water temperatures, and increased streamflows or flood frequency due to loss of forest cover, especially on south facing watersheds. Numerous programs are underway to improve habitat conditions on federal, state, and private lands, but it will take several decades for the full benefits of these actions to accrue.

The Forest Service manages habitat for listed fish species on federal forestlands through several programs, including the Northwest Forest Plan and PACFISH/INFISH[29] Biological Opinions. The State of Washington's Forest Practice Rules address forest habitat conditions and functions needed for listed fish on non-federal lands, but there is some uncertainty as to the long-term adequacy of these rules to address all major ecological processes that maintain properly functioning habitat for all life stages of listed fish species. These efforts to regulate forestry activity will need to be reviewed to ensure that they adequately protect listed species and their habitats.

Managing the existing networks of forest roads so as to minimize watershed impacts will continue to be a priority. Timber companies are disposing of large blocks of private forestland in the Yakima Basin. Efforts to work with landowners to maintain economically viable working forests that also sustain steelhead habitat will be an important part of larger efforts to reduce fragmentation of the landscape.

Climate Change

The regional climate in the Northwest may be changing in response to global atmospheric changes. Scientists predict reduced winter snow pack, increased winter rainfall and increased summer drought. These changes affect fish populations when changes in precipitation and snow pack patterns directly affect streamflows and when higher

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[29] PACFISH is the Interim Strategy for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, and Portions of California. INFISH is the Interim Strategy for Managing Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana, and Portions of Nevada.

summer temperatures result in more evapotranspiration and increased water temperatures. Actions in this plan, including maintenance of habitats in high elevation areas, restoration of hydrology and passage, and improvement of riparian zones may reduce the effects of global warming. Climate change may also make colder habitats that are currently unsuitable for steelhead more suitable. The potential impacts of global climate change are recognized at national and international levels. The risks of global climate change are potentially great for Yakima Basin stocks because of the sensitivity of salmon stocks to climate-related shifts in the position of the sub-arctic boundary, the strength of the California Current, the intensity of coastal upwelling, and the frequency and intensity of El Nino events (Yakima Subbasin Fish and Wildlife Planning Board 2005). These changes could have significant effects on the success of recovery actions and the status of listed fish populations in the Yakima Basin (Climate Impacts Group 2009; Mastin 2008). Understanding and responding to changes in climate will be an important part of long-term recovery actions.

In-basin Harvest

Impacts of current fisheries in the basin are of two sorts: 1) incidental take during legal fisheries, and 2) illegal take and harassment. Both occur, but neither is considered a primary limiting factor for steelhead at this time. Past recreational steelhead fisheries had significant impacts on the run, with harvest levels ranging from 14% to 68% of the run between 1983 and 1988 (Yakima Subbasin Fish and Wildlife Planning Board 2005, p. 2-193). The harvest rate dropped in the late 80s and early 1990s, and the Yakima River and its tributaries were closed to steelhead fishing in 1994.

Current legal fisheries in the basin are highly regulated to reduce negative impacts on steelhead. Selective gear rules (no bait, single barbless hooks) for trout fishing are in effect in other tributaries known to support bull trout and steelhead spawning and rearing (e.g., Yakima River upstream of Roza Dam, Taneum, Swauk, Teanaway, Naches, Little Naches, Bumping, Rattlesnake, and American rivers). In some areas, including the Yakima River upstream of Roza Dam, the lower Cle Elum River, part of the Naches River and Rattlesnake Creek, trout fishing is limited to catch and release only. In remaining areas there are low catch limits for trout (generally two trout, minimum length 8 or 12 inches). Areas near the mouths of Toppenish and Satus creeks are closed for coho and fall Chinook during fall salmon fisheries to protect pre-spawning steelhead that hold in these areas during upstream migration. These regulations are designed to protect adult and juvenile steelhead and bull trout populations, while allowing economically important recreational fisheries for resident trout.

Despite these regulations, both incidental take and illegal harvest of steelhead occur. Angler interviews conducted by WDFW in the lower Yakima River during sport fisheries indicate that steelhead are incidentally hooked and released during Chinook and coho fisheries. Interviews suggest that there were between 13 and 146 steelhead caught and released each year during legal salmon seasons. Based on a 5% hooking mortality rate, this activity would kill up to seven steelhead in a given year. Both incidental take and poaching of steelhead during the winter fishery for whitefish pose a risk to steelhead adults holding prior to spawning. Starting in 2008, the winter whitefish fishery below

Granger was closed to protect holding steelhead, which are known to concentrate near the mouth of Satus Creek.

Loss of Nutrients from Anadromous Species

At the watershed scale, the loss of major contributors to the basin nutrient base, such as coho, sockeye, summer Chinook and components of the remaining steelhead and spring and fall Chinook populations, negatively affects the productivity of the ecosystem as a whole. Martin et al. (1994) suggested that low biomass in the Upper Yakima River may be related to low dissolved solids as expressed in conductivity measurements, but the correlation is not strong when certain other rivers are considered. Specific nutrients may correlate better with productivity, and salmon carcasses have been found in a number of studies to be a major source of these nutrients. Lowered ecosystem productivity has selective effects on steelhead life history (by reducing the tributary food base and selecting for shorter tributary residence), further reducing the potential for longer-term juvenile rearing within the basin. The lack of understanding about the actual effects of reduced nutrient transport by anadromous fish is a key knowledge gap identified in Chapter 7.

Reduction in Beaver Activity

In the Yakima Basin, the abundance and distribution of American Beaver (*Castor canadensis*) have been greatly reduced. Beaver have a tremendous influence on salmonid habitat quantity and quality. Loss of beaver dams has reduced the number of pools and straightened, widened, and incised channels. Streams have become disconnected from their floodplains and LWD supplies to streams have been diminished. The loss of beaver activity also alters sediment routing, stream temperature and hydrograph, and riparian zone composition and productivity. The loss of the ecological functions that beavers provide directly diminishes salmon productivity (Lichatowich 1999). These effects occur in both the upper watershed and in side channels along downstream river reaches.

Increased Predation

Fish, mammals, and birds are the primary natural predators of steelhead in the Yakima Basin. Although the behavior of steelhead precludes any single predator from focusing exclusively on steelhead, predation by certain species can be seasonally and locally significant. Recent changes in predator and prey populations along with major changes in habitat conditions have reshaped the role of predation (Li et al. 1987). Better understanding predation dynamics is identified as a knowledge gap in Chapter 7.

Non-native salmonids with the potential to prey on steelhead include hatchery-strains of rainbow, brook trout, and brown trout, all of which are found in upper parts of the Basin.[30] In the lower mainstem Yakima, introduced bass and catfish prey on steelhead, although the smolt out-migration occurs during periods that are cooler than optimal for

[30] WDFW ended stocking of brook trout and brown trout in the Yakima Basin in 2006 and now only stocks rainbow trout in lakes.

bass and catfish, and multiple years of bass diet data from the lower Yakima showed that bass generally do not prey on yearling-sized salmonids (Fritts 2004; Fritts 2006).

Changes in ecological dynamics caused by habitat changes have also increased predation by native species. Northern pikeminnow (a native fish whose abundance has increased due to more favorable habitat conditions under current river management) has the greatest potential to negatively affect the abundance of juvenile salmonids in the Yakima Basin. The pikeminnow is a large, opportunistic predator that readily adjusts feeding patterns to prey availability. Most adult salmonids within the Yakima Basin are opportunistic feeders and are therefore capable of preying on juvenile steelhead and bull trout. Native salmonids likely to have some effect on the survival of juvenile salmonids include adult bull trout, rainbow/steelhead trout, and cutthroat trout. Native species such as sculpins also prey on salmonid eggs and juveniles (Hunter 1959; Patten 1962; Patten 1971a; Patten 1971b).

Predation risk is also linked to water temperature. Studies have indicated predation rates increase at higher temperatures (Collis et al. 2000a; Gray and Rondorf 1986; NMFS 2000). Predation and high temperature may be acting synergistically to increase selection pressure on juvenile outmigration, although steelhead are considered less vulnerable than other salmonid species to piscine predators.

Avian predation on fish contributes to the loss of migrating juvenile salmonids in the Yakima River Basin. Fish-eating birds that occur in the Yakima Basin include great blue herons (*Ardea herodias*), gulls (*Larus spp*.), osprey (*Pandion haliaetu*s), common mergansers (*Mergus merganser*), American white pelicans (*Pelecanus erythrorhynchos*), double-crested cormorants (*Phalacrocorax spp*.), Caspian terns (*Sterna caspia*), belted kingfishers (*Ceryle alcyon*), black-crowned night herons (*Nycticorax nycticorax*), Forster's terns (*Sterna forsteri*), hooded mergansers (*Lophodytes cucullatus*) and bald eagles (*Haliaeetus leucocephalus*) (Stephenson and Fast 2005). These birds have high metabolic rates and require large quantities of food relative to their body size.

Yakama Nation data (J. Siegel, personal communication, 2006) point to common mergansers as the primary avian fish predator in the Yakima River from Keechelus Dam downstream to Roza Dam, and white pelicans as the primary avian predator from Roza Dam to the Columbia River, with a significant gull population at Wanawish (Horn Rapids) Dam. These estimates are based primarily on census data multiplied by consumption rates from the literature and are not prey species-specific. However, *O. mykiss* is only a significant component of the fish biomass in the Yakima River upstream of Roza Dam (G. Temple,WDFW, communication 2006).

Mammals may be an important agent of mortality to steelhead in the Yakima Basin. Predators such as river otters (*Lutra canadensis*), raccoons (*Procyon lotor*), mink (*Mustela vison*), and black bears (*Ursus americanus*) are common. These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Otter-killed adult steelhead are frequently found along Satus Creek during spawner surveys (B. Rogers, YN, communication 2006). Black bears generally scavenge spawned-out salmon.

Increased Competition with Native Species

Increased competition can occur not only between steelhead and introduced species that did not co-evolve, but also between steelhead and other native species. This happens when anthropomorphic induced habitat change alters competitive relationships. For example, Reeves et al. (1987) found that redside shiners dominated juvenile steelhead at warmer temperatures. Thus, where habitat changes result in increased water temperature, increased competition with shiners may affect steelhead.

Human-caused changes in the relative abundance of native species can also change competitive interactions. For example, although coho salmon were native to the basin, the species was extirpated by the early 1980s. Recent efforts to re-establish coho (Hubble et al. 2004) and the ongoing supplementation of Chinook populations in the Yakima Basin are providing an opportunity for research on possible human-induced changes in competitive interactions. As noted in Section 3.5.1.11, however, these reintroduced coho and supplemented Chinook may also have the beneficial effect of importing oceanic nutrients into the basin.

Recent analyses (Pearsons et al. 2004) of the potential effects of reintroduced species on steelhead and bull trout have found some depression of rainbow and steelhead mean size at age since coho reintroduction and spring Chinook supplementation began in the Yakima Basin. However, preliminary results of Yakima/Klickitat Fisheries Project (YKFP) research indicate that this trend was not related to supplementation activities. This YKFP research continues.

Increased Disease

A variety of bacterial, viral, fungal, and microparasitic pathogens can infect steelhead. Numerous diseases may result from pathogens that occur naturally in the wild or are transmitted to wild fish by infected hatchery fish. Infectious hematopoietic necrosis virus, bacterial kidney disease (BKD) (*Renibacterium salmoninarum*), coldwater disease (*Flavobacterium psychrophilum*), and columnaris (*F. columnare*) have all been identified in salmonids in the Yakima River (BPA Division of Fish and Wildlife 1990; Pearsons and Thomas 2003; Yakima Indian Nation et al. 1990). Beginning as early as mid-April in water-short years, water temperatures in the lower Yakima River are in the range favorable for the development and serious progression of infectious salmonid diseases (Fryer and Sanders 1981; Jobling 1981). Steelhead are more resistant to BKD than are other salmon species, although Foott (1992) found high incidence of BKD in wild steelhead populations in the Trinity River.

Sublethal chronic infections can impair the performance of steelhead in the wild, thereby contributing to mortality or reduced reproductive success. Fish weakened by disease are more sensitive to other environmental stresses and may become more vulnerable to predation (Hoffman and Bauer 1971) or less able to compete with other species. When Reeves et al. (1987) found that water temperature affected competitive interactions between redside shiners and steelhead, they determined that the outcomes of interactions were, in part, related to infection with *F. columnare*. In their study, most steelhead were infected at warmer temperatures, whereas shiners showed a higher incidence of infection at cooler temperatures.

Increased Gaps Between Populations

Gaps between steelhead populations are assumed to have increased with the advent of irrigation, water storage, and floodplain development. Disproportionate decreases in abundance and productivity in lower tributaries of the Naches and Yakima rivers, (e.g., Cowiche Creek on the Naches; and Wenas and Umtanum creeks on the Yakima), along with increased mortality of the progeny of mainstem spawners due to flow manipulation and habitat damage, are believed to have widened the gaps between the Upper Yakima, Naches, and Satus steelhead populations. However, spawning in the Toppenish Creek watershed was probably limited to upper reaches throughout the Holocene epoch; also, spawning appears to be more prevalent today in the upper Yakima River mainstem than previously assumed (Karp et al. 2003; Karp et al. 2005). Whether successful spawning occurs in the Yakima below the Naches confluence is unknown and is identified as a knowledge gap in Chapter 7.

Genetic Impacts of Past Hatchery Management

Introduction of hatchery-origin rainbow trout or non-local steelhead from mixed Columbia Basin or Skamania stocks subjected all steelhead populations to some degree of genetic risk. During the 20th century, steelhead from several sources were introduced into the Yakima Basin; the predominant one was the Skamania stock from the Washougal River. In the mid-1980s, the Yakama Nation and WDFW agreed to produce fish from wild Yakima broodstock. Between 1985 and 1989, the Yakama Nation trapped broodstock at Prosser Dam for spawning, egg incubation, and rearing at the WDFW Yakima hatchery, with assistance from the Northwest Steelheaders and Trout Unlimited. The co-managers agreed to discontinue wild broodstock collection after 1989 because of the low smolt-to-adult survival rate and the inability to select population-specific broodstock at Prosser Dam. From 1990 through 1992, a small number of adult Yakima Basin steelhead were trapped and their progeny reared by YKFP researchers to evaluate species interactions in the upper Yakima River. Hatchery-produced steelhead smolts were last released in the Yakima Basin in 1993 (Fast and Berg 2001). Although these practices no longer occur, interbreeding with hatchery fish may have reduced the genetic fitness of some steelhead populations.

Introductions of resident rainbow trout are believed to have contributed to the decline of the anadromous form of *O. mykiss* in the upper Yakima. Genetic introgression from non-indigenous hatchery trout populations into the rainbow trout population of the upper Yakima is believed to have occurred (Phelps et al. 2000). Because interbreeding of resident rainbow and steelhead has been observed in the field (Pearsons et al. 1998), this introgression likely has also occurred in what remains of the upper Yakima steelhead stock. There is less evidence of introgression into the Naches stock (Phelps et al. 2000). While planting of hatchery trout has ceased, the continued presence of non-native genes in the rainbow population presents genetic risks to steelhead.

3.3.2 Lower Mainstem Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the lower mainstem Yakima (from the mouth to the Naches confluence), see Table 3.2. These threats are discussed in more detail below.

Altered Streamflows

Low flows in much of the lower Yakima River combine with high air temperatures, degraded riparian vegetation, and reduced floodplain function to create extended river reaches with water temperatures that exceed the physiological tolerances of native salmonids. Native and non-native predatory fish tolerate these conditions well and may be more efficient predators under these conditions. Additionally, poor water quality conditions in the lower Yakima River can lead to increased mortality rates in steelhead and other native anadromous smolts from water-borne pathogens (BPA Division of Fish and Wildlife 1990; Pearsons and Thomas 2003). High water temperatures persist in the lower Yakima River throughout the irrigation season. Migrating adult steelhead must hold on the Columbia River near the mouth of the Yakima River until the river cools in late summer or fall.

Changes in flow and associated temperature regimes may have had a strong selection effect on all populations of steelhead during both upstream migration (delaying adult entry to the system) and the downstream migration (truncating the smolt run and kelt outmigration in late spring/early summer). Steelhead life histories that include both short- and long-term juvenile rearing in the lower mainstem are no longer viable due to high temperatures, reduced water quality, and the resulting loss of summer rearing habitats in the lower mainstem Yakima.

Floodplain Alteration

The lower mainstem Yakima River flows through extensive floodplains in the Union Gap and Wapato reaches. Highways, railroads, and dike systems have cut off significant portions of the floodplain, reducing floodplain function and the availability of side-channel habitat. Stanford et al. (2002) identified the Union Gap reach as having the greatest potential for floodplain restoration. The Bureau of Reclamation's YRBWEP program has acquired significant amounts of floodplain property and is working with the county, the city of Yakima, gravel mine operators, and others to significantly improve floodplain function in this reach. In lower reaches of the Yakima, residential development along the river and associated alterations to natural riparian vegetation are becoming increasingly common. Little attention has been given to the floodplain reaches in the Tri-Cities area near the mouth of the Yakima River.

Creation of False Attraction Flows

Hydropower wasteways, such as Roza Power Plant Wasteway, irrigation drains, and spillways, including Sulphur Creek Wasteway and Marion Drain, discharge flow that can entrain or confuse adult steelhead during the upstream migration period. This can result in stranding of fish in unsuitable habitat and/or delays in upstream migration.

Reduced Water Quality

Degraded water quality (especially pH, dissolved oxygen [DO], and temperature conditions) significantly reduces habitat quality in the lower Yakima. Intensive agricultural production, including drainage improvements, and the use of fertilizers and pesticides have left a legacy of contamination (i.e., DDT and DDE in aquatic sediments and arsenic and lead in the soil profile), and residual concentrations of nutrients (i.e., phosphorus in lower river sediments), which may diminish only slowly over time.

Throughout the irrigation season, the lower Yakima River (downstream from Granger, RM 82) receives large volumes of irrigation return flows (Johnson et al. 1986; Rinella et al. 1999; Rinella et al. 1992). In 1997, the Roza Sunnyside Board of Joint Control initiated a water quality improvement program for drains and wasteways in the lower Yakima River, making significant strides at improving water quality in the lower river. In particular, fine sediment discharge has been reduced, although not eliminated.

The recent explosive growth of water star-grass in the lower Yakima River has led to concerns about its effect on water quality (especially dissolved oxygen), habitat, and migration conditions for salmonids. Growth of this native plant may have been augmented by advances in controlling suspended sediments, which increased light-penetration into the water column, and by long periods without bed-scouring high flows.

The Washington Department of Ecology (WDOE) has placed 72 watercourse segments throughout the Yakima Basin on the most recent 303(d) list (in 1998) of threatened and impaired water bodies (WDOE 1998). Primary impairments leading to these listings included increased temperatures, high agricultural pollutant concentrations (e.g., 4,4'-DDE, DDT, dieldrin, 4,4'-DDD, chlorpyrifos, endosulfan, and PCB), dissolved oxygen deficits, and a host of other water quality constituents (e.g., arsenic, mercury, silver, fecal coliform, pH, ammonia, chlorine, turbidity, and phosphorous) that are generally detrimental to fish health and persistence (Johnson et al. 1986; Morace et al. 1999; Rinella et al. 1999; Rinella et al. 1992). Current agricultural trends may result in reduced water use (e.g., conversion of large areas to wine grapes), but also increased nutrient loading and waste (e.g., from expansion of the dairy industry and other confined animal feeding operations). Recent dramatic improvements in water quality in the lower river have shown that concerted efforts by all parties can reduce agriculture’s impacts on water quality.

Predation by Introduced Species

Non-native fish species can prey on juvenile salmonids. Smallmouth bass have the greatest potential to negatively affect the abundance of juvenile steelhead in the lower mainstem of the Yakima. They are large, opportunistic predators that readily adjust their feeding patterns to prey availability. Abundant channel catfish also have the potential to prey on juvenile salmonids. WDFW currently has no catch limits on bass in the Yakima River, although only bass less than 12" or greater than 17" may be retained, of which no more than one may be over 17". There are no catch limits for channel catfish. Smolt outmigration generally occurs in conditions that are cooler than optimal for bass, as noted under predation in Section 3.3.1, but some overlap occurs. Better estimating the impacts of predation by bass is identified as a research need in Chapter 7.

Impaired Fish Passage

Significant work has been done to ensure fish passage at major irrigation diversions in the mainstem Yakima River. However specific seasonal operations and flow conditions at some diversions with fish ladders can still hinder adult upstream migrations. There is also significant uncertainty over the impacts of diversion structures on the survival of downstream migrating smolts, with some structures known to cause physical injury and/or concentrate predation (e.g., Horn Rapids (Wanawish) Dam and the Chandler Canal screen entrance and bypass outfall).

3.3.3 Satus Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Satus Creek Watershed, see Table 3.3. Loss of floodplain habitats, reduced riparian zone health caused by intrusive roads and poor grazing management practice, and increased peak flow and sediment loads from forestry activities, including an extensive network of forest roads, have all diminished habitat productivity in this system. The Yakama Nation has had an active watershed restoration program in this basin since the 1980s.

Floodplain Alteration

The lowest eight miles of Satus Creek (below Mule-Dry Creek) have been simplified and confined to increase agricultural acreage. Although excavation and filling essentially ceased in the late 1980s, impacts to channel morphology and function remain (Ringer and McCoy 1998). Farther upstream, State Route 97 crosses Satus Creek five times and confines it for several miles. Riparian roads parallel several tributaries, confining stream channels and acting as alternative drainage systems.

Grazing Impacts

Fencing, off-stream water development, and conservation leasing of key riparian parcels have largely addressed negative impacts from cattle grazing, but wild horses have a heavy impact on wide areas of the watershed. Tributary wet meadow systems have become incised through loss of stabilizing vegetation, woody debris, and reduced lower beaver activity.

Forestry Impacts

Increased peak flows and sediment loads from forestry activities and the associated network of forest roads negatively affect Satus Creek. Work is ongoing to address road-related issues in the watershed.

Altered Streamflows

Streamflow in Satus Creek is essentially unregulated. The four irrigation diversions present on Satus Creek in 1980 were all shut down by 1991 to protect instream flows. In dry summers, the creek can still dry up for several miles within the alluvial reach upstream of the Logy Creek confluence (mile 23.6). Past grazing practices and extensive flooding in the early 1970s and 1990s have degraded floodplain conditions; ongoing

efforts to improve floodplain and upland function will be required to improve flow conditions.

Impaired Passage

The Wapato Irrigation Project's abandoned Satus diversion dam may act as a partial barrier to steelhead passage. A complete passage barrier exists where Highway 97 crosses Shinando Creek. Other barriers may exist on small tributaries in association with forest road networks.

Reduced Water Quality

Most of the Satus Creek watershed is undeveloped and is not exposed to agricultural, industrial, or domestic effluents, but because of degraded riparian habitats and low flows, maximum weekly average temperatures can exceed 26^{o}C in the Satus Creek reach between Logy Creek and Wilson Charley Creek (RM 39.3). Logy Creek may cool Satus Creek for a few miles downstream from their confluence. Water quality suffers (although water quantity increases) as Satus Creek flows through the Wapato Irrigation Project (WIP) in its lower eight miles. Improved management of return flows would increase conditions in the lower eight miles of Satus Creek. The relatively young and rapid steelhead outmigration from Satus Creek described in an earlier section appears to be a population response to harsh summer conditions.

3.3.4 Toppenish Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Toppenish population area, see Table 3.4. Reduction in habitat productivity in this system is related to loss and alteration of floodplain habitats in lower Toppenish Creek, altered surface water/groundwater interactions in lower Toppenish Creek, altered flow characteristics on the alluvial fan of Toppenish Creek, reduction in flow and passage barriers in the Simcoe/Wahtum/Agency creek systems, and increased peak flow and sediment loads from forestry activities.

Floodplain Alteration

The Toppenish Creek channel historically assumed an anabranched appearance downstream of the Simcoe Creek confluence and flowed through an extensive network of wetlands for nearly 30 miles to the Yakima River. This system has been simplified to facilitate agriculture, grazing, and management of waterfowl habitat. Between RM 45 and the Simcoe Creek confluence (RM 32.7), diking, channel straightening, installation of drains, and low-capacity crossings have caused alternating deep incision and heavy deposition as the creek traverses its alluvial fan, reduced riparian vegetation, and compromised floodplain function.

Channel conditions upstream of the mouth of Toppenish Canyon are considered to be significantly better than in the downstream reaches. Riparian roads associated with timber harvest and the loss of beaver dams have straightened, widened, and incised the channel upstream of the mouth of Toppenish Canyon and degraded riparian conditions in the canyon portion of the watershed. Rapid deposition of gravel behind new channel grade

controls just below the canyon indicates more rapid erosion upstream than managers had assumed.

Altered Streamflows

The Toppenish Lateral Canal (TLC) at RM 44.2 historically diverted all flow in the creek from mid-June to mid-October. Despite recent adherence to a 10-cfs minimum flow requirement below the TLC diversion, natural seepage of up to 18 cfs into the expansive Toppenish Creek/Mill Creek alluvial fan results in a dry reach by late summer for several miles downstream from the three-way diversion. Most of the seepage does not reappear downstream before WIP return flows enter Toppenish Creek. A portion of the loss appears to seep into Simcoe Creek, which wraps around the toe of the fan, although seepage from the creek and from the TLC cannot be easily distinguished at this location. Other possible sinks are Harrah and Marion drains and large irrigation wells in the underlying basalt, which may be in communication with the fan. Despite this loss, the perennial section of stream downstream from the dam provides summer habitat for approximately 2,000 juvenile steelhead.

Two irrigation diversions downstream from the TLC supply Unit 2 and the Satus area of the WIP, primarily using return flows routed into Toppenish Creek via Mud Lake and Marion drains. Marion Drain, which is much deeper than Toppenish Creek for much of its length, intercepts subsurface flows that once entered the creek from the north.

The North Fork of Simcoe Creek provides the majority of flow in the Simcoe Creek watershed. Four private diversions and a WIP diversion (Simcoe Feeder Canal) historically took most of the base flow of Simcoe Creek. Since 2002, the Yakama Nation has worked to maintain minimum instream flows below all five Simcoe Creek diversions.

Reduced Water Quality

High water temperatures in lower Toppenish, Simcoe, and Agency creeks have resulted from diversion of annual spring flooding, draining of wetlands, riparian degradation, and the large volume of warm water irrigation returns routed from WIP down Simcoe and Toppenish creeks. As in Satus Creek, stream temperatures increase with proximity to the mouth of Toppenish Creek, with the highest weekly average temperature among four stations in 2004 approaching 24 degrees Celsius at a point 10 miles above the mouth. Data from the summer of 2007 indicate some cooling below stream mile 10 that may be related to upwelling. Temperatures in Marion Drain are about 6°C cooler in the summer and 5°C warmer in the winter than temperatures in the mainstem. This thermal moderation is attributable to the large proportion of groundwater in the drain; before the drain was constructed much of this groundwater presumably flowed into nearby Toppenish Creek.

Impaired Passage

In February 2006, Yakama Nation personnel confirmed that a private road crossing of Toppenish Creek just upstream from the Simcoe Creek confluence was impeding adult steelhead passage at moderately high streamflows of several hundred cfs. This crossing has the potential to hinder passage into the entire Toppenish Creek spawning population.

Several other passage barriers and unscreened diversions exist in Simcoe Creek and other tributaries.

Grazing Impacts

Fencing, off-stream water development, and conservation leasing of key riparian parcels have largely addressed negative impacts from cattle grazing, but wild horses have a heavy impact on wide areas of the watershed. Tributary wet meadow systems have become incised through loss of stabilizing vegetation and woody debris and lower beaver population size and activity.

Forestry Impacts

Increased peak flows and sediment loads from forestry activities and the associated network of forest roads affect the Toppenish Creek system. Work is ongoing to address road related issues in the watershed.

3.3.5 Naches Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Naches population area, see Table 3.5. These threats are discussed in more detail below:

Floodplain Alteration

Most of the braided, alluvial floodplain reaches in the Naches system have been altered by highways, gravel pits, levees, local roads, agriculture, irrigation diversions, and rural and urban development, with the most severe impacts on the lower Naches below the Tieton confluence. The diversity of channel types in the Naches River upstream from the Tieton River confluence (RM 17.5) has been greatly reduced. Basalt canyon walls, riprapped dikes, road embankments, and revetments confine the upper channel. Bedload movement is apparent in some of the more narrowly confined reaches of the upper Naches River, and right-bank revetments, which protect homes, have cut off historic side channels and spring brooks.

Downstream from the Tieton confluence, the Naches River floodplain widens, although a highway and other structures have isolated the river from part of the active floodplain. Floodplain activities and structures (e.g., highways, gravel pits, levees, local roads, agriculture, irrigation diversions, rural and urban development) have degraded, removed, or altered the functional condition of the river-floodplain ecosystem.

The lower Little Naches River and the lower Bumping River are confined by highways and associated levees, which constrict floodplains and cut off historic side channels and meanders.

Channel Simplification

As noted earlier, changed flow regimes in the Tieton River combine with its natural confinement to simplify its channel. Tieton Dam captures the river’s main source of gravel, and the remaining gravel supply is readily transported by high flow. Because of unsuitable conditions in the mainstem Tieton, Oak Creek is the only portion of the Tieton

River watershed currently occupied by steelhead. Sections of the Little Naches have also been simplified by a highway that runs alongside the river for much of its length.

Impaired Passage

Tieton Dam has inundated or blocked the most productive habitats in the Tieton River drainage, which comprises a fourth of the entire Naches watershed, and Bumping Dam blocks six miles of upstream habitat. Telemetry data and spawning ground surveys suggest that only a small number of adult steelhead now reach the base of these dams, probably because upstream migration coincides with reservoir filling and low river discharge, which is most pronounced in the Tieton River, Migration efforts are further compounded by poor passage at the Yakima-Tieton diversion dam (RM 14.2). Modifications to the fish passage facilities at the Yakima-Tieton Diversion Dam are scheduled for completion in 2008. Passage into Cowiche Creek was eliminated or greatly reduced through the 20th century, but recent diversion improvements have reopened that watershed. Partial passage barriers have also been removed from the Ahtanum Creek watershed, and similar work is ongoing in Rattlesnake, Nile, and Wide Hollow creeks. Passage into other Naches tributaries is generally unimpaired.

Grazing Impacts

In the middle and upper portions of Cowiche Creek, Ahtanum Creek, and other mid-elevation tributaries, livestock have negatively impacted riparian zones by grazing and trampling streambanks. Cooperative projects with livestock managers have reduced grazing impacts in many of these areas. Extensive sheep grazing in the late 19th and early 20th centuries also significantly affected upland and riparian conditions throughout the Naches population area.

Forestry Impacts

Past forest practices and road networks have been affected Ahtanum and Cowiche creeks; ongoing efforts to manage and improve road systems will be needed. The upper watershed of the Little Naches River has been heavily logged. Spawning gravel is abundant in the Little Naches River and tributaries, although deposition of fine sediments increased after the initiation of large-scale clear-cutting. The lower 4.4 miles of the Little Naches River now afford the poorest spawning and rearing habitat in the drainage due sedimentation and confinement by roads and levees. Fine sediment in spawning substrates may be declining since an apparent peak in 1993 (Muir 2003).

Streamside Recreation

The upper Naches River watershed is a popular recreation area. Activities, which include recreational mining, establishment of dispersed camp sites, and off-road vehicle use, have had major impacts on various streams, streamside habitats and species, increased sedimentation, reduced riparian and floodplain function, and reduced abundance and spatial structure of listed species. Impacts have been greatest in the Little Naches and American River watersheds, but recent efforts by the USFS and others are significantly moderating these impacts.

Altered Streamflows

Flow regimes in the Naches Basin and associated tributaries can be put into three groups: 1) the highly modified flows of the Tieton and Lower Naches rivers; 2) the relatively natural flow regimes of the Naches and its tributaries above the Tieton River and of tributaries above Rimrock and Clear lakes; and 3) the lower tributaries subject to irrigation withdrawals, such as Cowiche, Ahtanum, and Rattlesnake creeks.

The Tieton River has the most skewed hydrograph of all Naches River tributaries, varying from less than 100 cfs, while the Rimrock Lake reservoir is filled from late October through March to nearly 2,000 cfs when the reservoir supplies most of the Yakima Project's irrigation demand each September as part of flip-flop operations. These flow effects persist downstream, with Naches River discharge rapidly quadrupling in late summer as the Tieton Dam gates are opened. This rapid increase in flow in the Tieton and lower Naches during a time of year when natural flow fluctuations would be uncommon is likely to displace and even injure or kill early juvenile steelhead, which are not large enough to maintain position in high river flow. Although flip-flop flows in the lower Naches may open access to side- and off-channel areas that could be used by juvenile steelhead, the rapid increase and decrease in flow can cause dewatering and stranding. Monitoring is needed to understand what happens when these conditions occur. From October through early summer, the Naches, Tieton, and Bumping rivers are flowing below estimated unregulated stream flow levels, which also affect salmonid habitat values.

During the summer months, irrigation withdrawals reduce flows in the lower Naches River, decreasing the availability of rearing habitat. Recently, the BOR and WDOE acquired the Wapatox hydropower site and its water right. Flows that formerly were diverted for power generation at this site are now remaining in-stream in a critical low-flow reach of the Naches River. However, the Wapatox Canal also serves irrigators, and their requirement for conveyance water limits the quantity of water that can be placed instream.

In contrast to the Tieton and the lower Naches, the Naches River and its tributaries upstream from the Tieton River still exhibit a largely normative flow regime, regulated only by the relatively small Bumping Lake reservoir.

Cowiche, Ahtanum, lower Nile, and Rattlesnake creeks have numerous irrigation diversions, which significantly reduce summer and fall flows, and at times have dried up portions of the creek beds. In recent years, significant efforts have been made to secure instream flows in Cowiche and Ahtanum creeks. The small steelhead subpopulation in Ahtanum Creek was mostly ignored through a century of over-appropriation and dewatering of the lower reaches, but appears to be responding to recent efforts to maintain a summer flow of 10 cfs throughout the mainstem.

Rattlesnake Creek provides good to excellent habitats in its middle and upper reaches. In the lower reaches of Rattlesnake Creek, irrigation diversions, low flow associated with floodplain loss, and the accumulation of coarse sediments limit habitat availability and diversity.

Impacts from Increased Development

Rapid population growth and development is occurring in Yakima County (including the cities of Yakima, Union Gap, Selah, Moxee, and outlying rural areas). In the Ahtanum Creek watershed, along the Naches River above the Tieton, and parts of the Cowiche Creek watershed, residential or recreational home development is often located adjacent to streambanks. Near the cities of Yakima and Union Gap, agricultural lands, many with shallow groundwater, are being converted to residential, commercial, and industrial uses. Conversion of agricultural lands to other uses will be accompanied by fragmentation of ownerships and land uses, each with different management goals. The probability of conflict between new land owners/land uses and floodplain/stream channel functions (which sustain fish habitat and conveyance of water and sediment) is high.

3.3.6 Upper Yakima Population Threats and Limiting Factors

For an overview of the threats and limiting factors that occur in the Upper Yakima population area, see Table 3.6. These threats are discussed in more detail below:

Floodplain Alteration

The once extensive floodplains of the Upper Yakima in the Easton, Cle Elum, Ellensburg, and Selah reaches contained multiple channels and large areas of spawning and rearing habitat for steelhead. Roads, including I-90, railroads, and dikes associated with agriculture, development, and gravel mining have constricted these floodplains. Near Ellensburg significant efforts are being made to reopen access to side channel habitat that has been incorporated into irrigation systems.

Impaired Passage

Passage barriers have significantly reduced the habitat available to anadromous steelhead in the Upper Yakima population area. Cle Elum, Kachess, and Keechelus dams block all upstream movements and allow only limited downstream movements. Cle Elum Dam has inundated or blocked an important component of Yakima River tributary steelhead habitat, the BOR estimating that 29.4 miles of potentially useable anadromous habitat are located upstream of Lake Cle Elum ((BOR 2005).

A number of tributaries to the Upper Yakima River (e.g., Swauk, Wilson, Naneum, Big, Little, Taneum, Manastash, Tucker, Cooke, Caribou, Coleman, and Reecer creeks and the Teanaway River) are likely to have historically supported steelhead, but impassable dams, dry reaches below dams and unscreened and inadequately screened diversions have eliminated steelhead from many of these tributaries. Diversion structures at Tucker, Naneum, Manastash, Cooke, and Caribou creeks were built without passage facilities. In many cases (e.g., Manastash, Taneum and Naneum creeks), the forested watersheds above the agricultural zone support very good habitat. Low flows and unstable channel conditions, including the construction of recreational dams during the summer migration season, also inhibit movement of steelhead in the Teanaway River.

Roza Dam is a potential bottleneck for outmigrating smolts. When runoff is low, the design of the Roza spillway gates hinders downstream passage for fish that miss the

bypass, as the only available passage is a narrow slot underneath the gates. Under these conditions, significant concentrations of smolts have been observed in the pool above the dam. Delays can result in immediate mortality, residualization, or delaying arrival in the lower Yakima River until periods when low flow, high temperature, and increased predator activity reduce survival.[31] BOR has recently been "tucking" a spillway gate at Roza Dam to allow surface spill when river flow permits and is evaluating options for modify the spillway gates so that surface spill can take place at lower river flow.

Historically Roza Dam was also a seasonal barrier to migrating adults moving upstream. Every year between 1939 and 1958 when winter power diversions were first begun, the Roza Dam forebay was kept at minimum elevation for significant periods between mid-October and mid-March. The fish ladder was operational only at full pool, while the spillway was and is impassable at all pool levels. Based on the University of Washington's DART database, between 1999 and 2009, 20% of the steelhead passing Roza was counted between November 1 and March 15. These data, collected since power diversions and associated winter ladder operations were initiated, suggest that a significant proportion of the steelhead bound for the Upper Yakima prior to 1958 may have been delayed or prevented from reaching their destination due to the seasonal ladder closures.

The original Roza Dam fish ladder only operated at full pool levels. A new ladder was installed at Roza Dam in 1989 that allows passage at minimum pool and full pool levels, but there is no passage at levels between these extremes, which occur while the pool, is being drained or filled (a period of days a few times a year). There is also the possibility of reduced passage at Easton Dam in dry years when BOR guidelines call for closing the dam's fish ladder in the spring to prevent spring Chinook from spawning in sections of the Upper Yakima that will not have sufficient winter flows to protect the redds. Closure of the Easton Dam fish ladder has not occurred since 1996.

Although major water diversions are screened, numerous unscreened diversions exist on tributaries. These are being addressed in conjunction with efforts to remove passage barriers and improve riparian conditions in the lower reaches of tributaries in the Ellensburg area.

Altered Streamflows

Unnaturally low flows in the Upper Yakima and Cle Elum rivers when reservoirs are being filled may inhibit steelhead migration and spawning. An emphasis on reservoir refill in water-short years may also result in low winter and spring streamflows that affect the extent and quality of juvenile rearing habitat. More data are needed on the impact of reservoir fill timing and associated low flows on adult and juvenile migrations and juvenile steelhead rearing environments.

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[31] While empirical data on the constraints to juvenile passage at Roza are primarily available for hatchery Chinook smolts, the same conditions are expected to be encountered by outmigrating steelhead.

There are large releases of water into the Upper Yakima and Cle Elum rivers during the summer irrigation season. As discussed in Section 3.5.1.3, this may both reduce growth and survival of young-of-the-year steelhead and promote residency for older juveniles. Due to the flip-flop regimes, significant portions of streambed along the Upper Yakima and Cle Elum rivers are dewatered within a week in early September, with likely adverse effects on benthic macroinvertebrates and juvenile native and anadromous fish (Arango 2001; James et al. 1999; Pearsons et al. 1996). Pearsons et al. (1996) surveyed juvenile salmonid (including steelhead) use of side channel habitat in the Cle Elum and Upper Yakima rivers, and determined that 3 of the 21 monitored side channels and sloughs were totally dewatered and another was disconnected from the main channel after flip-flop. The authors concluded from this indirect evidence that nearly all juvenile salmonids they found in these side channels before flip-flop were likely killed because of rapid dewatering (83% flow reduction in two weeks). Monitoring is needed to understand what happens when these conditions occur.

Irrigation diversions have dewatered the lower reaches of many tributaries (e.g., Swauk, Teanaway, Taneum, Manastash and Big creeks), creating flow and temperature conditions that reduce juvenile rearing capacity. Efforts to secure instream flows in these reaches are ongoing. Other tributaries (e.g., the Reecer and Wilson creek systems) have flows that have been significantly increased in summer due to their use for irrigation water conveyance.

Simplification of Natural Waterways Used for Conveyance

In the Wilson/Naneum and Currier/Reecer creek systems in the Kittitas Valley, tributaries and side channels have been highly modified to facilitate use as part of irrigation distribution systems. This has resulted in simplification of channel structure due to 'ditch' cleaning, diking, and removal of vegetation. These areas are also typically subject to passage barriers by numerous diversions and to degraded water quality. Habitat that was once suitable for rearing and, in some cases, for spawning has often been rendered inaccessible and/or inhospitable. The Kittitas County Conservation District, Yakama Nation, Kittitas Conservation Trust, and others are working to open up many of these areas.

Reduced Water Quality

Although water quality in the Upper Yakima Basin is generally much better than in the lower basin, irrigation effluents and flow regulation have adversely affected some areas (Joy 2002; Joy and Patterson 1997). The Upper Yakima and Cle Elum rivers, as well as tributaries to the Yakima River in the Kittitas Valley (e.g., Cherry, Cooke, Wilson, Taneum, and Manastash creeks), are 303(d)-listed for numerous water quality problems.[32] Seasonal decreases in natural flow, along with added irrigation effluents expose regulated reaches to high late-summer ambient temperatures, suspended sediments, agricultural pollutants, and other adverse water quality constituents, including

[32] For more information on 303-d listings see the Department of Ecology's State Water Quality Assessments at http://www.ecy.wa.gov/programs/wq/303d/index.html

fecal coliform bacteria, low dissolved oxygen, and elevated nutrients. These issues are most pronounced in the Wilson Creek system.

Forestry Impacts

Past forest practices and road networks have affected many parts of the Upper Yakima; ongoing efforts to manage and improve road systems will be needed. Because of its south-facing aspect and its steep, confined tributaries, the Teanaway watershed is especially prone to increases in peak flow resulting from changes in watershed condition associated with forest road networks and timber harvest activities. Recovery planners consider the Teanaway River to be the highest priority in the basin for identifying and reducing impacts from forest practices.

Grazing Impacts

Past and current grazing practices have negatively affected riparian conditions in many of the mid-elevation tributaries to the Upper Yakima River. Cooperative efforts to work with livestock managers to address remaining impacts are ongoing.

Streamside Recreation

The Upper Yakima Population Area contains a number of popular streamside recreation areas. Recreational mining, establishment of dispersed campsites, and off-road vehicle use have increased sedimentation and reduced riparian and floodplain function on various streams, streamside habitats, and species within the basin. These conditions have contributed to the reduced abundance and productivity of listed fish species.

Impacts from Increased Development

Kittitas County and cities within the county, such as Ellensburg, Cle Elum, Ronald, Roslyn, and others, are experiencing rapid population growth and associated development. In many areas, forest and agricultural lands are being converted to residential development. Development immediately adjacent to the mainstem river and to tributaries can result in reduction or elimination of riparian zones and increase flood hazard. Adjacent to the city of Ellensburg, agricultural lands (many with shallow groundwater) are being converted to residential, commercial, and industrial uses. Conversion of agricultural lands to other uses will be accompanied by fragmentation of ownership and land use. The probability of conflict between new land owners/land uses and floodplain/stream channel functions (which sustain fish habitat and conveyance of water and sediment) is high.

3.4 Out-of-Basin Threats and Limiting Factors

Conditions in the Columbia River, its estuary, and the Pacific Ocean significantly affect the productivity, abundance, and life history diversity of Yakima Basin steelhead. In its All-H analysis, NOAA Fisheries is estimating the survival rates for the Middle Columbia Steelhead DPS from the mainstem Columbia to the ocean and back. There are currently no estimates of the effect of out of basin factors on the other VSP metrics for Yakima steelhead populations. The BPA, the Corps of Engineers, the BOR, NOAA Fisheries,

WDFW, Tribes, and others are implementing actions to improve survival of anadromous fish in the Columbia and the ocean. Current and proposed actions are being assessed as part of development of a new Biological Opinion for the Federal Columbia River Power System.

This plan focuses on conditions within the Yakima Basin, but understanding how in-basin actions interact with these out-of-basin factors is crucial to understanding the potential effectiveness of our in-basin actions. This requires monitoring out-of-basin survival rates for Yakima Basin steelhead populations (see Chapter 7).

While this plan does not address out-of-basin impacts on Middle Columbia River Steelhead in detail, a brief overview of significant issues is given below. Areas where impacts on Yakima Basin steelhead may be different from impacts on Middle Columbia River Steelhead as a whole are highlighted.

3.4.1 Out-of-Basin Effects on the Lower Yakima Basin

Conditions immediately beyond the mouth of the Yakima River influence conditions for steelhead in the lowest part of the Yakima River. The mainstem Columbia now provides excellent habitats for exotic species such as smallmouth bass and catfish, which migrate into the lower Yakima and may increase in-basin predation risk. The diverse habitat of the Yakima River delta, which once included an extensive forested riparian zone and numerous side channels, has been degraded and partially submerged by McNary Pool, an adjacent portion of the Columbia River upstream of McNary Dam. Changes to the Columbia River hydrograph may also affect the shared groundwater/surface water system of the Yakima River downstream of Wanawish Dam, where temperature extremes currently limit salmonid survival and diversity. These potential out-of-basin impacts on the Lower Yakima need to be studied to determine if they are negatively affecting listed species, and if so, how their effects can be reduced.

3.4.2 Columbia River Dams

Steelhead migrating to and from the Yakima Basin pass four Columbia River hydroelectric dams: Bonneville, The Dalles, John Day, and McNary. These dams are maintained for primarily hydroelectric production, navigation, and irrigation. They affect survival rates, migratory patterns, and timing of Yakima steelhead populations. Access and passage through these dams results in the direct mortality of both adults and juveniles at each dam. These dams have also significantly changed the nature of fish habitat in the Columbia above Bonneville Dam, replacing former rapids, pools, and riffles with wide, deep, slow-moving reservoir habitat. These impoundments affect the temperatures and travel times faced by migrating fish and result in increased exposure to predation. Extensive efforts are being made to improve the survival of anadromous fish through the Columbia River hydrosystem. The future of these actions is being negotiated as part of development of the revised Biological Opinion for the Federal Columbia River Power System.

3.4.3 Columbia River Estuary

The Columbia River estuary is a key habitat where juvenile and adult fish make the physiological transition from fresh to saltwater and vice versa. Pearcy et al. (1992) found that environmental conditions encountered by juveniles in the ocean, which includes the estuary and the river plume, are important predictors of the success of a brood year and the overall adult return rates.

The Columbia River estuary has been extensively modified. Estuary habitat has been lost due to dredging of a shipping lane, diking and the sedimentation and active filling of side channels (Weitkamp 1994). Dredge spoils have been used to create artificial islands in the estuary, which fish eating birds (e.g., Caspian terns, Double-crested Cormorants and gulls) use as nesting, resting, and foraging grounds. Upriver dams have created reservoirs that act as settling ponds, reducing the delivery of sediment and organic matter to the estuary (Sherwood et al. 1990). The cumulative effects of urbanization, industrialization, agricultural practices, and dams have degraded water quality in the estuary.

Prior to flow regulation, spring freshets created an immense freshwater plume at the mouth of the Columbia during the time that smolts were entering the ocean. Conditions within the plume may protect juvenile salmon making the transition to the ocean. The freshwater-saltwater margins of the plume provide key feeding areas. Reduction in the spring flows from the Columbia River has greatly reduced the size of the plume and its influence on nearshore marine conditions (Sherwood et al. 1990) and is believed to reduce survival conditions for emigrating juvenile salmonids (Pearcy 1992).

3.4.4 Ocean Conditions

Listed steelhead from the Yakima Basin spend a significant portion of their lives and accumulate most of their body mass in the marine environment. About half the mortality to salmonids occurs in the ocean (Bradford 1995). Conditions in the ocean affecting survival are subject to short-and long-term variation and are a source of significant variation in salmon returns to freshwater (Beamish and Bouillon 1993). Specific understanding of the marine ecosystem inhabited by Columbia Basin salmon and steelhead is limited. However, it is clear that short- and long-term cycles drive marine productivity and salmon survival. These cycles are the result of forces acting across the Pacific Ocean that affect currents, temperature, upwelling, and nutrients in coastal areas inhabited by Yakima Basin steelhead. Short- and long-term changes in marine productivity cascade through the food chain and affect salmonid abundance. Annual fluctuations in ocean survival make the potentially positive effects of freshwater restoration actions difficult to detect. At the same time, the negative effects of habitat degradation may be masked by improving marine conditions, leading to deeper reductions when the ocean subsequently shifts to a regime of poorer conditions (Lawson 1993).[33] The need to evaluate smolt-to-adult and adult-to-smolt ratios to separate out the influences of in- and out-of-basin conditions is highlighted in section 7.2.2. The effects of

[33] Much of the background information on lower river, estuary, and ocean effects is taken from the Snake River Salmon Recovery Plan (2005).

ocean conditions on Yakima Basin steelhead will be incorporated into NOAA Fisheries' all-H analysis for the Middle Columbia River Steelhead DPS as a whole. We are not aware of any aspects of ocean survival that are distinct for Yakima steelhead stocks when compared to Middle Columbia River Steelhead as a whole.

3.4.5 Out-of-Basin Harvest

Harvest in the Columbia River, estuary, and ocean fisheries has historically been a major limiting factor for anadromous fish in the Yakima Basin. Current commercial, recreational and subsistence fisheries are managed to minimize impacts on listed stocks, but some level of incidental mortality in mixed-stock fisheries is known to occur. Better estimating the impacts of fisheries in the Columbia will help us understand the degree to which harvest affects in-basin returns.

3.4.6 Predation

The altered environments of the mainstem Columbia and its estuary support a variety of both native and non-native predators. Changed river conditions have increased predation by native northern pikeminnow, while introduced species like walleye and bass also prey on migrating smolts. Avian predators such as Caspian terns, Double-crested Cormorants and gulls also have significant impacts (NMFS 2000). The creation of artificial islands in the Columbia River estuary from dredge spoils attracts opportunistic fish-eating birds, which feed on juvenile salmonids migrating from the Columbia River to marine habitats (Antolos et al. 2005). In the Columbia River estuary, avian predators are estimated to have consumed 18% (range, 11-30%) of smolts (all species) reaching the estuary in 1998 (Collis et al. 2000b). Relocation of nesting terns from Rice Island to East Sand Island has resulted in a reduction of the percentage composition of salmonids in their diet (Collis et al. 2002).

Yakima steelhead populations are exposed to out-of-basin avian predation that other Middle Columbia River Steelhead major population groups bypass because of the Yakima River's location. Bird populations on islands in the Columbia near the mouth of the Yakima are known to consume steelhead migrating out of the Yakima River. In 2005, an estimated 1% (22) of PIT tags from outmigrating Yakima River steelhead were subsequently recovered on the Crescent Island Caspian tern colony. In 2004, the figure was 2% (A. Evans, Real Time Research Inc., communication 2006). In 2005, only 0.1% (3 PIT tags) of PIT-tagged Yakima River steelhead were recovered on the Badger Island pelican colony (located just downstream from the mouth of the Yakima with >1057 adult birds present). PIT tag recoveries from the Foundation Island colony of double-crested cormorants, situated 8 km upstream of Crescent and Badger islands indicated an overall steelhead predation rate about 1/5 as great as for the tern colony, though this is changing as tern numbers drop and cormorant numbers increase (Collis and Roby 2006). These rates do not account for ingested PIT tags deposited off the colonies or for mortality of tagged fish (at least 50% for Yakima steelhead) between release sites and the Yakima River mouth.

Pinnipeds, including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Steller's sea lions (*Eumetopia jubatus*) are the primary marine

mammals preying on steelhead originating from the Yakima Basin (Spence et al. 1996). Pacific striped dolphin (*Lagenorhynchus obliquidens*) and killer whale (*Orcinus orca*) may also prey on adult steelhead. Seal and sea lion predation is primarily in saltwater and estuarine environments, although they are known to travel well into freshwater terrain in pursuit of migrating fish. While in recent years, significant numbers of sea lions have entered the Columbia River below Bonneville during the spring, they are not generally present during the July-August migration window for Yakima steelhead. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable. Although marine mammals and salmon coexisted long before man interfered ecologically, human alterations and management practices throughout the species' ranges have resulted in a reduction in salmon and steelhead abundance to the point that increased or targeted predation can have more significant effects on population viability.

3.4.7 Competition with Non-Native Species

A potentially important source of exploitative competition occurring outside the basin may be between the exotic American shad (*Alosa sapidissima*) and juvenile steelhead. Palmisano et al. (1993) concluded that increased numbers of shad likely compete with juvenile salmon and steelhead, resulting in reduced abundance and production of salmon and steelhead. It is also hypothesized that the large numbers of shad in the Columbia contribute to the growth of northern pikeminnow, smallmouth bass, and walleye, which are important predators of salmon and steelhead. Shad may be sustaining large populations of predators during periods when salmon and steelhead are not available to the predators, and, as a result, more and larger predators are present during periods when salmon and steelhead are moving through the Columbia River. Research is needed to assess the direct and indirect effects of American shad on the abundance and survival of Yakima Basin steelhead.

4 Recovery Goals and Criteria

4.1 Recovery Goals
4.2 Recovery Objectives & Criteria
4.3 Recovery Strategies

Recovering listed species requires reducing or eliminating threats to the long-term persistence of populations, maintaining widely distributed populations across the diversity of habitats in their native ranges, and preserving genetic diversity and life-history characteristics. According to current guidance from NOAA Fisheries, demonstrating recovery of the Middle Columbia River Steelhead will require showing that populations, MPGs and the DPS, have met certain measurable and objective criteria based on the Viable Salmonid Populations (VSP) framework (ICTRT 2004) and the threats criteria identified in the listing.[34] This chapter presents measurable goals, objectives, and criteria based on the four VSP parameters of abundance, productivity, spatial structure, and diversity and then describes general strategies for achieving these criteria. Specific actions that implement the general strategies are described in Chapter 5.

4.1 Recovery Goals

The overall goal of this plan is to ensure long-term persistence of viable populations of naturally produced steelhead distributed across their native range in the Yakima Basin. A "viable" population is defined as an independent population that has negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe. This recovery plan is build around three separate but linked sets of thresholds for assessing progress towards recovery: a delisting threshold, a short-term recovery threshold, and a long-term recovery threshold.

4.1.1 Delisting Threshold

The delisting threshold is based on the recovery scenarios identified by the ICTRT (2007a; 2007b) with minor modifications based on discussions between local recovery planners and the ICTRT. When these criteria and similar criteria for other MPGs within the Middle Columbia DPS are met, a proposal to delist the DPS is considered appropriate by the ICTRT. According to the ICTRT (2007b, p. 8), an MPG meeting the following five criteria would be at low risk:

1) At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.

2) At least one population should be classified as "Highly Viable."

3) Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as "Very Large," "Large," or "Intermediate," generally reflecting the proportions historically present within the

[34] See the Federal Register, Volume 71, p. 834.

MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.

4) All major life history strategies that were present historically within the MPG should be represented in populations meeting viability requirements.

5) Populations not meeting viability standards should meet or exceed the maintenance standard[35] with (a) sufficient productivity so the overall MPG productivity does not fall below replacement (i.e., these areas should not serve as significant population sinks) and (b) sufficient spatial structure and diversity demonstrated by achieving such maintenance standards.

Choices made by the Yakima Basin Fish & Wildlife Recovery Board in applying the ICTRT standards include presuming that 1) the Naches would achieve at least the Viable standard (meeting the ICTRT requirement for one of the large populations to be classed as Viable), 2) the Satus population is the most likely candidate for Highly Viable status, and that 3) the Toppenish and Upper Yakima populations would meet or exceed the maintenance standard for remaining populations. Other combinations that also meet ICTRT guidelines are possible, and if during implementation these seem more appropriate to pursue, the delisting strategy should be revised accordingly.

The Yakima Basin Fish & Wildlife Recovery Board also split the Satus Population into the Satus Creek and Mainstem blocks, as described in section 2.2. The Satus Creek block is attributed the number of spawners the ICTRT would have identified for a population based just on the habitat available in the Satus Creek watershed itself; planners believe that achieving “high viability” status for this block, using the criteria for a basic population, is likely. The “mainstem block” represents steelhead identified by the ICTRT as being potentially produced in the lower Yakima River portion of the Satus Population Area (from the Satus Creek confluence to the Columbia River). Given the uncertainties about both historic and future potential for significant amounts of spawning in this portion of the basin, the Board chose to treat that portion of the Satus population as a block of spawners that can be produced in the lower mainstem Yakima and its tributaries or in the portion of the mainstem Yakima upstream of Satus Creek and below the Naches River. If mainstem spawning in these reaches is not found to be viable, additional fish produced beyond the abundance thresholds in one or more of the other population areas can make up for the “mainstem block.”

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[35] The ICTRT calls for a “maintained” population to have an abundance/productivity combination above the 25% extinction risk on their viability curves and a spatial structure/diversity risk rating as per Figure 4.1, with the qualification that the minimum abundance threshold for a basic population should be 250 spawners and the minimum for intermediate through very large populations should be at least 500 spawners (ICTRT 2007b, p. 79).

4.1.2 Short-term Recovery Threshold

The short-term recovery threshold calls for recovering all four steelhead populations in the Yakima Basin to the ICTRT's Viable status (a 5% or less risk of extinction over a 100 year period). This threshold differs from the delisting threshold in that all populations must exceed maintained status and be classified as viable, and no population is singled out for Highly Viable status. This threshold was the one originally developed by the Yakima Subbasin Planning Board prior to development of the final ICTRT recommendations. It was retained in order to emphasize the Yakima Basin Fish & Wildlife Recovery Board's commitment to achieving viability across all four populations in order to minimize long-term extinction risks. The Board recognizes the delisting threshold as an appropriate point at which to consider delisting, but holds that continuing on beyond delisting to achieve the short-term recovery goal is both important and feasible in the 15-30 years needed to implement actions from this plan and see a population-level response by steelhead.

4.1.3 Delisting & Short-term Recovery Threshold Differences

The matrix presented in Figure 4.1 helps clarify the difference between the delisting and short-term recovery thresholds. The figure is adapted from the ICTRT's stock status reports (ICTRT In press); a full description of the ICTRT approach to determining Viability can be found in ICTRT (2007b).

Figure 4.1: VSP parameter risk ratings for Yakima steelhead populations

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/Productivity Risk	**Very Low (<1%)**	**HV**	**HV**	**V**	M
	Low (1-5%)	**V**	**V**	**V**	M
	Moderate (6-25%)	M	M	M Toppenish Satus	
	High (>25%)			Naches	Upper Yakima

HV = Highly Viable; V = Viable; M = Maintained; Shaded cells do not meet viability criteria

The short-term recovery threshold calls for moving all four of the Yakima Basin populations to a 5% viability level. Looking at the figure, this would require moving them from the lower right portion of the diagram to one of the boxes marked with a V in the second row. The ICTRT's viability criteria for the Yakima Basin Major Population Group (MPG) calls for two of the populations (including one of the large populations) to move to Viable status or better, with one of the Viable populations then moving on to Highly Viable status. The remaining two populations must reach or exceed Maintained status. The most likely scenario addressing these criteria was described in Section 4.1.1.

4.1.4 Long-term Recovery Threshold

Achieving the delisting and short-term recovery goals described above are only the first steps towards increasing the abundance and productivity of Yakima Basin steelhead populations to levels that allow for harvest for recreational, commercial, and ceremonial purposes in keeping with the Vision 2020 statement in Section 1.2. The specific long-term recovery targets identified in this plan are far from definitive determinations of what may be possible. They do serve to remind us that while the short-term goals of recovering steelhead to the point that they no longer require the protective measures of the Endangered Species Act is an immediate priority, the long-term recovery vision of the Yakima Basin Fish & Wildlife Recovery Board will require building on that initial success and continuing recovery efforts long after delisting is achieved. No time frame is set for achieving long-term recovery.

4.1.5 Relationship of Recovery Thresholds to NOAA Delisting Decisions

NOAA Fisheries' decision whether or not to delist Middle Columbia River Steelhead should be guided by the Board and ICTRT recovery thresholds, but is not required to be strictly determined by them. NOAA has the discretion to determine when it considers the MPG sufficiently recovered to be labeled as Viable. NOAA Fisheries also has the ability to proceed with delisting even if neither threshold is met, based on the determination that substantial progress towards recovery is being made. Because steelhead populations within the Yakima Basin make up only a portion of the total Middle Columbia River DPS, it is also possible that Yakima Basin steelhead meet their recovery criteria but are not delisted, based on concerns over the status of other steelhead MPGs in the DPS.

4.2 Recovery Objectives and Criteria

This section describes recovery objectives and criteria developed in accordance with NOAA Fisheries guidance (NMFS 2004) and the ICTRT Yakima Stock Status Assessments described in Chapter 2 (ICTRT In press). The purpose of these objectives and criteria is to provide concrete measures of progress towards meeting the recovery goals. These objectives and criteria are based on quantitative and qualitative measurements of abundance, productivity, and spatial structure/diversity on a population basis. Criteria for the delisting and short-term recovery thresholds are drawn directly from the ICTRT's Stock Status Assessments, with the delisting threshold based on the most likely application of the maintenance standard to one large population (Upper

Yakima) and one other population (Toppenish), and the short-term recovery threshold based on achieving Viability for each of the four populations. Productivity and diversity criteria for the long-term recovery threshold are the same as for the short-term threshold. Long-term recovery threshold abundance and spatial structure criteria are based on restoring full access to historically accessible stream reaches throughout the basin that that can be restored consistent with the Board's commitment to sustaining local customs and economies.

4.2.1 Abundance

The abundance objective is to maintain the number of steelhead within each population in the Yakima Basin at levels consistent with viability. The abundance criteria call for maintaining the 10-year geometric mean for spawner abundance at levels equal to or exceeding the values given in Table 4.1.

Table 4.1: Minimum abundance criteria for recovery thresholds

Population	Delisting Threshold	Short-Term Recovery	Long-term Recovery
Satus: Satus Watershed Mainstem Block[36]	 500 500	 500 500	 2,000
Toppenish	250	500	1,500
Naches	1,500	1,500	5,400
Upper Yakima	500	1,500	7,700
Total for MPG	3,250	4,500	16,600

The long-term recovery targets presented here were calculated by averaging and rounding the results of the 2005 subbasin planning EDT restoration threshold for steelhead and an extrapolation to spawner abundance from the ICTRT total weighted and temperature limited habitat area for the Yakima Basin (discussed in Sections 2.3 and 2.4.1) times an average of 10 spawners per 10,000 m^2 of high-quality habitat (a rate currently seen in good habitat in the Yakima Basin) as shown in Table 4.2.

[36] As noted in Section 4.1.1, the "mainstem block" represents spawners attributed to the Satus population by the ICTRT that local recovery planners call for producing either in the portion of the mainstem Yakima below the Naches River, or if mainstem spawning in these reaches is not found to be viable, as additional fish produced beyond the abundance thresholds in any of the population areas.

Table 4.2: Sources for long-term recovery abundance targets

Population	EDT Restoration Scenario	ICTRT Expansion	Average of EDT & ICTRT
Satus	2,733	1,280	2,007
Toppenish	1,784	1,171	1,478
Naches	4,911	5,849	5,380
Upper Yakima	6,533	8,795	7,664
Total	***15,961***	***17,095***	***16,528***

Note that these numbers do not take into account interactions with resident rainbow

Although the total abundance target for the long-term recovery threshold is approximately an order of magnitude greater than recent 10-year average abundance, it is still only one third of the estimated historic abundance levels discussed in Section 2.4.1. Both methods assume that the anadromous form of *O. mykiss* dominates the entire Upper Yakima population area. Reviewing this assumption is identified as a key research need in Chapter 7. These long-term abundance targets should not be interpreted as definitive goals. They are meant to encourage discussion and ongoing research about the potential size of fully recovered steelhead populations in the Yakima Basin.

4.2.2 Productivity

The productivity goal is to increase the number of reproductive offspring per spawner within each population to levels that, together with increased abundance, result in low risk of extinction. All thresholds call for the Yakima major population group to maintain a long-term average spawner:spawner ratio greater than or equal to 1.0, indicating stable or increasing long-term population size. Productivity criteria are based on intrinsic productivities calculated using the ICTRT's methods[37] in order to assess the ability of populations to rebound when reduced to below average abundances. Criteria for minimum 10-yr geometric means for intrinsic productivity at the size threshold for each population and threshold are indicated in Table 4.3. Criteria are based on the ICTRT Viability Curves (ICTRT 2007b).

[37] See explanation of ICTRT intrinsic productivity calculations in Section 2.4.2.3.

Table 4.3: Spawners and spawner:spawner ratio

Population	Delisting Threshold	Short-Term Recovery	Long-term Recovery
Satus: Satus Watershed Mainstem Block	 2.00 (High Viable) 1.56 (Viable)	 1.56 (Viable) 1.56 (Viable)	 1.2 1.2
Toppenish	1.20 (Maintained +)	1.56 (Viable)	1.2
Naches	1.26 (Viable)	1.26 (Viable)	1.2
Upper Yakima	1.20 (Maintained +)	1.26 (Viable)	1.2

4.2.3 Spatial Structure

The spatial structure goal is to restore the distribution of steelhead across a broad range of habitats in historically occupied areas in order to maintain resilience and life history diversity. Distribution of steelhead spawning across the ICTRT designated spawning areas for each population is used to assess spatial distribution. Distribution is assessed based on the ICTRT's definition of occupancy:

> Occupied areas are those in which two or more redds from natural origin spawners have been observed in all years of the most recent brood cycle (i.e., the most recent generation) and have been observed for at least half of the most recent three brood cycles (approximately 15 years for steelhead and Chinook). A Minor Spawning Area (MiSA) is regarded as occupied when it has two or more redds present over the previously defined time periods. A MSA is regarded as occupied when it has two or more redds within BOTH the upper and lower half of the weighted spawning area within that MSA over the previously defined time periods. (ICTRT 2007b, p. 50).

Satus Population

Naturally produced steelhead should occupy both major spawning areas in the Satus watershed (Satus and Dry Creek MSAs) and the Mule-Dry minor spawning areas. Consistent spawning must occur in both major spawning areas.

Toppenish Population

Naturally produced steelhead spawning should occupy both of the major spawning areas in the Toppenish watershed (upper Toppenish and Simcoe MSAs). Consistent spawning must occur in both major spawning areas.

Naches Population

Naturally produced steelhead should occupy at least seven of the eight major spawning areas for the delisting and short-term recovery thresholds. For the long-term recovery threshold all eight will be occupied. Consistent spawning must occur within the Naches

mainstem and Ahtanum, and Rattlesnake creeks to maintain distribution across habitat types and life histories.

Upper Yakima Population

Naturally produced steelhead should occupy at least 10 of the 14 major spawning areas for the delisting and short-term recovery thresholds. For the long-term recovery threshold 12 of 14 MSAs should be occupied. Spawning should consistently occur within at least the Yakima mainstem; Umtanum, Swauk, Manastash, and Taneum creeks; and the Teanaway River (West and North Teanaway MSAa and Lower Teanaway minor spawning area). While this threshold does not specifically require passage at Cle Elum, Kachess, and/or Keechelus dams, it recognizes that providing passage can play an important role in meeting these criteria. Table 4.4 summarizes the options for meeting the spatial structure criteria in the Upper Yakima.

Table 4.4: Possible combinations of spawning areas for the Upper Yakima

Required MSAs	Plus at least three of these:	Recovery not required
Umtanum Swauk North Teanaway West Teanaway Taneum Manastash Upper Mainstem	Cle Elum Naneum Reecer MSA Caribou MSA Middle Mainstem	Wenas Roza/Burbank

4.2.4 Diversity

The diversity goal for all thresholds is to maintain and enhance both phenotypic (morphology, behavior, and life-history traits) and genotypic diversity while limiting introgression of non-local genes. This will be accomplished by continuing to carefully manage and/or minimize factors that alter the distribution of traits such as timing of spawning and upstream and downstream migrations, age structure, size, fecundity, morphology, behavior, and genetic characteristics.

Population-specific criteria based on measurable traits, including body length, run timing, age structure, sex ratio, and genetic composition have not been developed at this time. As noted in Chapter 2, data is available on these traits for the MPG as a whole, but only the Upper Yakima population can be characterized in any detail at this time (based on samples at Roza Dam). Developing methods to identify fish by population at Prosser Dam fish ladders will play an important role in developing the information base needed to develop population specific diversity criteria. Additional information on the research needed to develop detailed population-specific diversity criteria is given in Chapter 7. The hatchery stray rate into the basin should be maintained at less than 5% of the total spawner abundance in the MPG (based on Prosser counts). Monitoring of genetic composition to detect the presence of non-indigenous genetic markers should be established.

4.3 Recovery Strategies

This section describes the geographic priorities and action strategies that will need to be applied to successfully meet the recovery goals, objectives, and thresholds described above. It provides an overview and framework for the more detailed discussion of specific recovery actions in Chapter 5. The action strategies were chosen to serve as a linkage between the specific action descriptions in this plan and the more general summary in the draft NOAA Fisheries recovery plan for the Middle Columbia River Steelhead DPS. These strategies are specific to the Yakima Basin; additional strategies to address factors affecting Yakima steelhead in the Columbia River and the ocean will be addressed in the NOAA Middle Columbia River Steelhead Recovery Plan.

Recovery strategies for the Yakima Basin are:

4.3.1 Habitat Strategies

1) Protect existing functional habitats
2) Restore unimpeded upstream and downstream fish passage (includes screening diversions)
3) Restore floodplain connectivity and function
4) Restore channel structure and complexity
5) Restore riparian condition and future LWD recruitment
6) Improve flow conditions
7) Improve water quality
8) Improve upland watershed conditions
9) Enhance upstream nutrient supplies

4.3.2 Predation Strategies

1) Reconfigure infrastructure to reduce predation
2) Evaluate and modify predator management options

4.3.3 Harvest Strategies

1) Maintain in-basin fishing regulations that protect steelhead, including regulations of other fisheries aimed at eliminating by-catch of steelhead and reducing negative impacts of introduced species

4.3.4 Hatchery Strategies

1) Use small-scale supplementation to accelerate recovery
2) Promote repeat spawning of kelts

All of the actions in Chapter 5 are classified according to the action strategies they implement and the limiting factors they address.

4.3.5 Recovery Strategies Outside of the Yakima Basin

Recovery actions in the mainstem Columbia, estuary, and ocean are identified and implemented through a complex framework of federal and state programs and policies over which Yakima Basin stakeholders have little control. The choice of which out-of-basin recovery actions to implement and the rate that they are completed will significantly affect the survival of Yakima steelhead during their upstream, downstream, and oceanic migrations. This plan focuses on recovery strategies within the Yakima Basin, but assumes that significant improvements will also be made out-side of the basin. Out-of-basin strategies and actions are to be addressed in detail as part of NOAA's Middle Columbia Steelhead Recovery Plan.

4.3.6 Recovery Strategies Affecting All Yakima Populations

All four Yakima populations will benefit significantly from efforts to improve conditions for upstream adult and downstream smolt migrations in the mainstem Yakima River. This will require:

1) Altering irrigation delivery and storage operations in the Yakima Basin to improve flows and temperatures in migration periods (Habitat Strategy 6) and utilize managed high flows to maintain floodplain habitat

2) Improving channel and floodplain conditions and reducing predation through the shared migratory reach (Habitat Strategies 3, 4 & 5 and Predation Strategy 1)

All four Yakima populations also benefit from the kelt-reconditioning program (Hatchery Strategy 2), protective fisheries regulations (Harvest Strategy 1), and ongoing efforts to protect existing functional habitat (Habitat Strategy 1). The Upper Yakima and Naches populations would also benefit from the conservation-oriented supplementation programs under consideration (Hatchery Strategy 1).

4.3.7 Role of Areas Above Storage Dams in Steelhead Recovery

When the five major Yakima Basin storage dams were constructed early in the 20th century, steelhead access to streams above the dams was blocked. The BOR has assessed the amount of anadromous fish habitat potentially available if passage facilities are built as 13.8 miles above Keechelus Dam, 2.4 miles above Kachess Dam, 29.4 miles above Cle Elum Dam, 6.0 miles above Bumping Lake Dam, and 36.8 miles above Tieton Dam ((BOR 2005). There is some uncertainty over the degree of productivity and past use of these areas by steelhead (Yakima Subbasin Fish and Wildlife Planning Board 2005, p. 2-335), but this may be offset by the prospect that these colder waters could become more important refugia for steelhead if climate change leads to decrease flows and increased water temperatures at lower elevations. Even limited use of these areas would increase the viability of the populations through improvements in spatial structure and life history

diversity. If Chinook, sockeye, or coho also recolonize these habitats, the resulting marine-derived nutrients would benefit steelhead.

The costs of providing passage at the storage dams are substantial when compared solely to their potential benefit to steelhead. It is the contention of the Yakima Basin Fish & Wildlife Recovery Board that 1) recovery of steelhead to levels of viability sufficient to warrant delisting under the ESA may be feasible without restoration of access to habitat above the storage dams, but that 2) access at some or all of the storage dams would greatly facilitate the process of steelhead recovery. Accordingly, our recovery criteria for steelhead do not require establishment of spawning populations above the passage dams, but do recognize that passage at the storage dams can help in reaching steelhead recovery goals. Fish passage at some or all of the storage dams is a key component for both bull trout recovery and re-establishment of sockeye salmon in the Yakima Basin, and offers significant benefits to non-listed Chinook and coho. When the benefits for all salmonid species are considered, passage at the storage dams becomes a much higher priority than it would be for steelhead on their own. Construction of Lake Cle Elum and Bumping Lake passage facilities are identified as specific actions in Chapter 5. Passage at all five storage dams should continue to be assessed based on the full range of benefits it would provide.

4.3.8 Toppenish Population Recovery Strategies

Geographic Focus

Recovery efforts should focus equally on both MSAs and their shared migration corridor. No specific actions are identified for the Mill Creek minor spawning area, but it should benefit from the general watershed-wide and lower Toppenish Creek actions.

Key Strategies

Achieving recovery goals for the Toppenish Population will require:

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)

2) Significant efforts to improve passage, flows, and riparian conditions in Toppenish Creek and its tributaries (Habitat Strategies 2, 5, 6, 7 & 8)

3) Restoration of floodplain function in lower Toppenish Creek (Habitat Strategies 3 & 4)

4) Improving migration conditions in the mainstem Yakima River as detailed in Section 4.3.6

4.3.9 Satus Population Recovery Strategies

Geographic Focus

Within the Satus Creek watershed itself, recovery efforts should focus equally on both MSAs and their shared migration corridor. No specific actions are identified for the Mule-Dry minor spawning area, but it should benefit from the general watershed-wide

and lower Satus Creek actions. Within the mainstem Yakima portion of the ICTRT Satus Population Area, recovery efforts should focus on improving habitat and survival for upstream and downstream migration by all populations. Specific efforts to restore spawning aggregations in the lower mainstem and its tributaries should only occur if there is evidence that successful life history strategies based in the lower river and its tributaries currently exist or can be re-established.

Recovery actions in tributary drainages to the lower Yakima River are not identified in this plan. Portions of Snipes, Spring, and Corral creeks and Amon Wasteway[38] may have potential to produce steelhead (Romey and Cramer 2001), and some level of use by salmon and *O. mykiss* is known to occur (Monk 2001). These waterways were identified as parts of minor spawning areas in the ICTRT intrinsic potential analysis. However, as discussed in Chapter 2, flows in these waterways are dominated by return flows from irrigation systems. Evidence that they would not have sustained significant year-round flows prior to the establishment of irrigation is presented by Smith et al. (2006). The Kennewick Irrigation District provided the Yakima Basin Fish & Wildlife Recovery Board with aerial photographs of Amon Wasteway from 1948 and 1955 that show a dry channel prior to irrigation development in the surrounding area (letter sent 12/26/07). This plan does not require these areas to be managed for steelhead in order to meet recovery objectives; and local recovery planners have indicated to the ICTRT that these areas should not be included as part of modeled historic habitat (See Appendix A).

Management of these waterways for fish habitat values has been limited. The irrigation districts manage these waterways as part of their drainage infrastructure and are concerned about potential regulatory burdens. WDFW notes that maintenance of the drainage networks need not prevent the protection and management of these waterways as fish-bearing waters. If these interests can be reconciled in a mutually acceptable manner, maintaining and enhancing fish habitat in the lower ends of these waterways should be encouraged as part of improving migratory habitat in the lower river.

Amon Wasteway is currently the focus of significant conservation efforts by the Tapteal Greenway Association. If habitat conditions that sustain steelhead production can be maintained and mutually acceptable agreements regarding future management reached by the Kennewick Irrigation District, WDFW, and other key stakeholders, management of this area as steelhead spawning habitat may be possible. However maintenance of steelhead spawning in this area is not a prerequisite for recovery and delisting of Yakima Basin steelhead.

Key Strategies

Achieving recovery goals for the Satus Population will require:

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[38] Spring, Corral, and Snipes creeks and Amon Wasteway are referred to by the names used on the USGS 7.5 minute topographic maps. The first three are referred to as drainageways by local irrigation districts, while Amon Wasteway is often referred to as Amon Creek. The use of these names in this document is in no way meant to indicate any conclusions regarding ongoing disputes about the legal status of these waterways.

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)

2) Continuing ongoing efforts by the Yakama Nation to improve watershed and riparian conditions within the Satus drainage ((Habitat Strategies 5, 7 & 8)

3) Restoring floodplain function and channel complexity in lower Satus Creek (Habitat Strategies 3 & 4)

4) Improving migration conditions in the mainstem Yakima River as detailed Section 4.3.6

4.3.10 Naches Population Recovery Strategies

Geographic Focus

The recovery threshold presented in this plan requires steelhead occupancy in seven of the eight major spawning areas. Currently there is at least some level of use in all eight MSAs, though steelhead spawning in the Tieton MSA is only confirmed from Oak Creek and the portion of the mainstem Naches associated with this MSA. Re-establishment of steelhead spawning in the Tieton River would make a valuable contribution to long-term recovery, but is not required by the de-listing threshold described in this plan. Efforts to increase steelhead use of the lower Tieton will only become feasible if fall high flows associated with flip-flop can be addressed; restoring use of the Tieton and its tributaries above Tieton Dam would require providing both upstream and downstream fish passage at the dam (see discussion of storage dams in Section 4.3.1).

The location of the Ahtanum and Cowiche MSAs between the Satus and Toppenish populations and the remainder of the Naches population make them important components of the spatial diversity of the population and the Yakima MPG as a whole.

The ICTRT has identified two minor spawning areas, Wide Hollow and Moxie, in the Naches population area. The Wide Hollow spawning area may have the ability to support limited steelhead spawning, but irrigation conveyance, return flows, and surrounding urban development hinder spawning activity. Establishment of steelhead in Wide Hollow is not a required part of recovery thresholds presented in this plan. The Moxee spawning area identified by the ICTRT is not considered to have had sufficient flows to support steelhead spawning, as noted in Section 2.3.3. The recovery thresholds presented in this plan do not require the establishment of steelhead in the Moxie area. Managing the lower reaches of Wide Hollow Creek and Moxee Drain to provide rearing habitat for fish moving to and from the mainstem Yakima, however, would be beneficial to Naches steelhead recovery.

The Naches River upstream from the Tieton confluence is the only mainstem reach in the basin with flows that are currently in a nearly normative state. Increasing the availability and quality of habitat in this portion of the basin will help offset the loss or alteration of mainstem habitats in other portions of the basin.

EDT model results indicate that conditions in the Naches River for the 17.5 miles below the Tieton confluence have a steelhead mortality rate—compared to the predevelopment estimate—of more than five times that for the 27.1 miles of the Naches upstream from

the confluence. Most of the modeled impact is due to daily maximum river temperatures during the summer period before the flow spike associated with flip-flop. According to BOR flow data for water years 1995-1999, average regulated flow in the lower Naches was significantly lower than modeled average unregulated flow in July and the first half of August. Improving conditions in this reach will benefit all upstream MSAs. The purchase of the Wapatox water right by BOR (Sec. 3.3.5.7) is a significant step towards improving flows in this reach.

The 47-mile section of the mainstem Yakima included by the ICTRT in the Naches Population is a critical part of migratory and rearing habitat for both Naches and Upper Yakima steelhead. The degree to which it currently supports spawning that results in successful production of smolts is unknown. If successful life histories based on spawning in this area exist or can be established, the reach will be a candidate for meeting the "mainstem spawner" abundance objective identified in Section 4.1.1. The extent and viability of spawning in this mainstem reach is identified as a key knowledge gap.

Key Strategies

Achieving recovery goals for the Naches Population will require:

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)
2) Making significant efforts to protect and improve passage, flows, and instream and riparian conditions in tributaries (Ahtanum, Bumping, Cowiche, Rattlesnake, Nile and Little Naches watersheds) (Habitat Strategies 2, 5, 6, 7 & 8)
3) Addressing the effects on steelhead of reservoir operations and irrigation withdrawals that create winter/spring/early summer low flows and late summer/fall high flows in the Tieton, lower Bumping and lower Naches River (Habitat Strategy 6)
4) Improve floodplain function and habitat conditions in the mainstem Naches River
5) Improving migration conditions in the mainstem Yakima River as detailed in Section 4.3.6

4.3.11 Upper Yakima Population Recovery Strategies

Recovery planners recognize that the Upper Yakima River steelhead population has the highest risk of extinction of the four populations in the MPG and will likely require more time and effort to recover than the Satus, Toppenish, and Naches populations. Just achieving "maintained" status in accordance with ICTRT maintenance guidelines will require a significant commitment to recovery actions in the Upper Yakima.

Geographic Focus

The Upper Yakima has the largest, most complex and diverse spatial structure of the four population areas, with 14 major and 2 minor spawning areas spread across a wide range

of ecological settings. It is also the population with the most limited current distribution relative to the estimated historic distribution.

Lower Upper Yakima Tributaries

The ICTRT's Wenas Creek MSA is not required in the recovery thresholds identified in this plan. If passage and appropriate migratory conditions in lower Wenas Creek could be assured, the upper watershed could potentially support a significant amount of steelhead spawning. The significant challenges associated with restoring passage and migratory conditions mean that it is not considered a short-term priority in this plan. If conditions change such that restoring Wenas Creek becomes feasible (e.g., major changes to irrigation systems and Wenas Dam), or if it is clear that production from the higher priority areas identified in this plan will not be sufficient to meet recovery objectives, restoration of steelhead spawning in Wenas Creek should be given higher priority. Efforts to maintain the lowest reaches of Wenas Creek as off-channel habitat for fish in the mainstem Yakima should be continued. The Selah Creek portion of the ICTRT's Wenas Creek MSA is not considered by local recovery planners to have ever maintained the streamflow needed to support steelhead and is not considered a recovery priority.

The Umtanum Creek portion of the Umtanum MSA is a mandatory element of the recovery threshold. Umtanum Creek itself is the only tributary with near-natural flow and habitat conditions that supports steelhead in the lower portion of the Upper Yakima population (it is managed as part of WDFW's LT Murray Wildlife Area). Potential contributions of Umtanum Creek to overall abundance and productivity of the Upper Yakima population as a whole are minor, but its role in improving gene flow between steelhead populations and as an island of relatively intact habitat in the Upper Yakima make it an important component of the spatial structure and diversity of the Upper Yakima population. While no specific actions are proposed for Umtanum Creek (the last significant passage barrier was removed in 2005-6), maintaining current management and protections is a high priority. While Lmuma Creek (also included in the ICTRT's Umtanum MSA) has the potential to support limited steelhead spawning, priority should be on restoring conditions in the lower end for use as an off-channel refuge by steelhead in the mainstem Yakima. Roza and Burbank creeks were also identified as potential habitat by the ICTRT, but have intermittent flows and limited access because of alluvial fans at their mouths. Neither is required as part of this recovery threshold. Work by the Department of Defense and other landowners aimed at improving watershed conditions in these areas should continue based on the benefits to downstream areas.

Ellensburg Area Tributaries

The Reecer and Caribou MSAs both contain complex networks of small creeks, including Dry, Reecer, and Currier (Reecer MSA) and Cherry, Cooke, Coleman, Park, and others (Caribou MSA). These creeks have been managed for a century as part of a complex network of irrigation ditches and drains. The lower ends of these tributaries have high value as off-channel rearing habitat for the adjoining reach of the mainstem Yakima and are being restored to serve as such through YTHAP restoration efforts. These creeks have only limited spawning potential due to their low gradients and highly altered hydrographs.

The Naneum MSA includes the Naneum and Wilson creek systems. The upper Naneum Creek watershed includes significant amounts of potential habitat and is thought to have sustained steelhead spawning prior to development of the irrigation infrastructure that now blocks passage into the upper watershed. Several possible routes exist for opening up passage through the interconnected network of streams and irrigation ditches east of Ellensburg. Identifying the most effective route and prioritizing barrier removal and habitat actions through this route is a significant but feasible challenge. Ongoing efforts to restore passage in Wilson Creek upstream to the city of Ellensburg are opening access to valuable rearing habitat; however, the high cost and logistical challenges of opening Wilson Creek through the city make working further up on Wilson Creek a low priority.

Other Upper Yakima Area Tributaries

The Swauk Creek, North Teanaway and West Teanaway MSAs and the Lower Teanaway minor spawning area are the current tributary strongholds for steelhead production in the Upper Yakima (the Middle Fork Teanaway is a portion of the West Teanaway MSA). Maintaining these spawning areas is required to meet the Upper Yakima recovery threshold. Taneum Creek has high quality habitat that is currently partially accessible. Projects to assure unimpeded fish passage are underway. Manastash Creek is currently inaccessible to steelhead due to passage barriers at irrigation dams; cooperative efforts to remove these barriers and improve instream flows are underway. Both of these MSAs are anticipated to be consistent producers of the anadromous form of *O. mykiss* and are required components of this recovery scenario.

Mainstem Spawning Areas

The Middle Mainstem MSA between the Teanaway and Cle Elum rivers is currently accessible. The Upper Mainstem MSA includes the accessible reaches of the mainstem Yakima River upstream from the Cle Elum River, tributaries such as Big Creek, and up to 15 miles of currently blocked habitat above Kachess and Keechelus dams. The Cle Elum MSA is split into the accessible section below Cle Elum Dam and up to 30 miles of blocked habitat above the dam. All are candidates for recovery.

Key Strategies

The complex interactions between habitat conditions and anadromous and resident life histories of *O. mykiss* in the Upper Yakima will require ongoing monitoring and research aimed at understanding what conditions promote anadromy, and specifically, whether residency is more a reflection of favorable local habitat or unfavorable migration conditions. Research outcomes will guide restoration in addition to the obvious needs for improved passage. For example, if flow manipulation has a disproportionate effect on early juveniles, moderating its effects may shift the current balance toward anadromy.

Actions that are expected to benefit the Upper Yakima steelhead population include:

1) Continuing efforts to protect existing functional habitat (Habitat Strategy 1)
2) Providing unimpeded passage for steelhead in key tributaries (Manastash, Taneum and if feasible, Naneum and Cle Elum) (Habitat Strategy 2)

3) Improving outmigration conditions at Roza Dam (Habitat Strategies 2 & 6)

4) Addressing the effects of reservoir and irrigation system operations that create winter/spring/fall low flows and summer high flows in the lower Cle Elum and mainstem Yakima rivers (Habitat Strategy 6)

5) Protecting and enhancing floodplain conditions along the mainstem Yakima (Habitat Strategy 3)

6) Improving flows and instream and riparian conditions in tributaries and side channels (Habitat Strategy 4, 5, 6 & 9)

7) Improving migration conditions in the lower mainstem Yakima River as detailed in Section 4.3.6

5 Recovery Actions

5.1 Identifying & Describing Recovery Actions
5.2 Timeframe for Implementing Actions
5.3 Necessity/Sufficiency of Proposed Actions
5.4 Overall Cost of Recovery
5.5 Recovery Action Descriptions

5.1 Identifying and Describing Recovery Actions

This chapter of the recovery plan recommends specific recovery actions that will contribute directly to restoring steelhead in the Yakima Basin to viable levels. Research and monitoring actions are described in Chapter 7, and outreach and education actions are described in Chapter 8. Both of these sets of actions do not directly alleviate threats to steelhead viability, but are essential to improving our ability to design and implement actions that do. Implementation of the recovery actions identified in this chapter should restore steelhead populations to viable levels. These actions will also benefit other fish species and some wildlife and lessen the chance for additional listings in the Yakima Basin.

Some of the actions identified in this plan were developed in other forums or processes (e.g., the Yakima Subbasin Plan and the HB 2514 Watershed Planning process) and are incorporated with little or no modification. Specific restoration actions that have been completed and are not ongoing in nature are not listed here; an inventory of past restoration actions was included in the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2005); and the Yakima Basin Fish & Wildlife Recovery Board anticipates maintaining a continually updated database of completed recovery actions. Intensive fish restoration work has occurred in the Yakima Basin for over three decades and continuing, refining, and expanding these existing efforts will be a key component of steelhead recovery in the Yakima Basin. Recovery will also require a significant commitment to new actions. Both new and ongoing actions are detailed in this plan. The following NOAA Fisheries recovery planning guidelines were applied when selecting and describing recovery actions (NMFS 2004):

- Recovery actions should be discrete and action-oriented.
- Whenever possible, recovery actions should be site-specific, as per ESA Section 4(f)(1)(B)(i).
- Recovery actions should be feasible and fundable.
- The plan should include both near-term (completed in less than 15 years) and long-term (taking longer than 15 years) actions.
- Recovery actions should be described with sensitivity and discretion.

Actions identified in this plan are classified into six groups, Basinwide, Lower Mainstem, Naches, Status, Toppenish, and Upper Yakima. Basinwide actions are those that can be applied throughout the basin. Most are programmatic in nature, though a few key

basinwide actions involve specific proposals for river and hatchery operations. Lower Mainstem actions are site-specific actions in the shared migratory corridor from the mouth of the Yakima upstream to the confluence of the Naches. Actions below the Toppenish Creek confluence are noted as benefiting all population areas, while those above are noted as benefiting the Naches and Upper Yakima populations.

All other actions are population-specific; where actions occur in and/or specifically benefit individual Major Spawning Areas (MSAs), these areas are indicated in the action description. Note that while MSAs are often named after a single creek, they typically include a complex of nearby creeks. For example, the Caribou Creek MSA also includes Coleman, Parke, Cooke, Cherry, and other creeks (see figure 2.5 for clarification).

As noted in Chapter 4, for local planning purposes we have broken the ICTRT's Satus population area into two components. The Satus Creek actions listed here are specific to the Satus Creek Watershed, while actions in the lower mainstem Yakima (technically part of the ICTRT's Satus population) are listed separately due to their broad benefits to all populations. Similarly, while the ICTRT Naches population area includes the Yakima mainstem from the mouth of Toppenish Creek upstream to the Naches confluence, we have included actions in this area under the mainstem actions category.

Additional information provided for each recovery action includes:

- Key partners
- Focal area
- Strategies implemented by the action
- Likelihood of implementation
- Time to implement
- Time to realize benefits
- Cost estimates

Key partners are entities likely to play a significant role in implementing the action.

Focal area is the location of the action itself.

For strategies implemented by the action, see Chapter 4.

Likelihood of implementation was scored in one of three categories. Only actions in the first two categories were retained:

- High (action is technically feasible, support is likely and there is little or no opposition)
- Moderate (action is technically feasible, there is some support, and opposition could likely be resolved)
- Low (action involves substantial technical issues and/or has little apparent or likely support or would likely encounter opposition)

Time to implement indicates the time required to implement the action on the ground. Categories were:

- Ongoing (action is in place and needs to be continued at roughly current levels)
- Expand ongoing effort (action is in place but needs to be expanded)
- 0-3 years required to implement
- 4-6 years
- 6-10 years
- Greater than 10 years

Time to realize benefits indicates the time needed following implementation for benefits of the action to be fully realized. This time ranges from instantaneous (e.g., improved passage is available the day after a dam is removed) to decades long (e.g., for plantings to generate new woody debris).

Cost estimates given in this plan are preliminary estimates based on the best information on hand. The accuracy of estimates varies greatly from action to action, and the estimates should not be taken as definitive. Each estimate represents the total cost of implementing the action, but does not include either the value of resulting benefits or opportunity costs incurred as a result of the action. The cost proportions indicate the percentage of the project costs attributed to benefiting fish in general and steelhead in particular. These are general estimates meant to indicate if a project would be done specifically to benefit steelhead (e.g., 100% fish, 100% steelhead), benefit steelhead and other fish species (e.g., 100% fish, 50% steelhead), or benefit fish indirectly (e.g., water conservation efforts that directly benefit irrigators in addition to their fish benefits).

Each action description is meant to give an overview of the proposed action and its key components. As part of the development of a recovery implementation schedule, action descriptions will be refined and expanded, and more detailed descriptions of specific components of the actions will be developed. This implementation schedule will be maintained in a tiered structure, with general strategies identified in this plan at Tier I (e.g., “Restore unimpeded fish passage”) and the actions described in this plan at Tier II (e.g., “Restore passage in lower Taneum Creek”). Tier III will include detailed descriptions of specific projects that implement the Tier II actions (e.g., “Install rock-weir fishway at the Bruton Diversion”). All of the actions described in this plan have been compiled into a simple database that will be regularly updated in response. See Chapter 6 for more information about how this will be integrated into the recovery implementation process.

5.2 Timeframe for Implementing of Actions

Actions in this recovery plan are intended to be implemented in the next 15 years. Recovery of the species themselves may take considerably longer (up to several decades) because of delayed environmental response (e.g., the time required for a planted riparian zone to reach maturity and full function) and subsequent population response (e.g., the

time required for a population to incorporate restored portions of its range into its life history). Actions are assigned to one of three time frames:

1) Actions classified as Ongoing are generally currently being undertaken by existing entities that have a history successfully implementing similar actions. In most cases ongoing actions will need to be continuously implemented in the future.

2) Short-term Actions are one-time or unique actions that can be implemented within the next six years.

3) Long-term Actions generally require additional technical study, policy review, and public comment prior to implementation. Implementation of these actions should begin within the 15-year time frame and continue thereafter. This requires that studies, policy review, and public involvement begin early in the implementation process. Specific timeframes for implementation of these long-term actions will be developed during the implementation scheduling process described in Chapter 6.

5.3 Necessity and Sufficiency of Proposed Actions

Given 1) natural variability in climate and ocean conditions, 2) uncertainty about the implementation and survival benefits of recovery actions in the ocean, estuary and mainstem Columbia, and 3) uncertainties about the rates and types of biological responses to within-basin recovery actions described in this plan, it is impossible to predict exactly which subset of the recovery actions described in the plan will be required to meet each of the separate goals of delisting, short-term, and long-term recovery. Implementing some or all of the actions presented here should significantly improve the abundance, productivity, spatial structure, and diversity of steelhead in the Yakima Basin. Recovery planners anticipate that the full suite of actions presented here, if combined with expected improvements outside of the Yakima Basin, will be more than sufficient to meet de-listing and short term recovery goals, but that additional actions may need to reach long-term broad sense recovery goals.

The Yakima Basin Fish & Wildlife Recovery Board is working with recovery stakeholders to refine the actions presented in this plan and developing a detailed Implementation Schedule that will be regularly updated to indicate the status of actions and identify priorities for future action based on their biological benefit and socio-economic feasibility. More detail on this process is given in Chapter 6.

Chapter 7 describes the monitoring and research efforts needed to track progress towards recovery goals and help us understand which recovery actions will be required to meet those goals. Evaluating the effectiveness of implemented recovery actions will require a rigorous and quantitative approach to adaptive management as priority actions are being implemented. Actual implementation efforts will have to be adjusted over time based on monitoring results. Detailed recommendations on implementing a strong adaptive management process will be included in the Research, Monitoring and Evaluation (RME) supplement to the Yakima Steelhead Recovery Plan that is currently being developed by the Yakima Basin Fish & Wildlife Recovery Board. Local recovery planners encourage

interested parties to participate in the development of the RME supplement and the ongoing adaptive management and implementation scheduling process.

This plan does not include a quantitative effort to analyze the sufficiency of the recovery actions recommended in this plan. At this time we do not have the level of detailed information needed to make quantitative predictions about the benefits of specific actions and the exact suite of actions that will be required to meet recovery goals. The Yakima Basin Fish & Wildlife Recovery Board and its partners will develop some of this detail as part of a regularly updated implementation schedule that identifies and prioritizes specific steps needed to implement the recovery actions in the Yakima Steelhead Recovery Plan. This process will focus on identifying specific habitat goals and tracking progress towards meeting them.

As part of development of NOAA Fisheries' Middle Columbia DPS Recovery Plan, the broad recovery scenario developed using the EDT model as part of the 2005 Yakima Subbasin Plan is being integrated into an all-H model that predicts steelhead response to recovery actions across the basin, the Columbia River, and the ocean. This EDT recovery scenario is described in Appendix B. More information about the integrated modeling effort will be available in the NOAA Fisheries' Mid-Columbia Steelhead Recovery Plan.

5.4 Overall Cost of Recovery

The cost identified for each action in this plan is a preliminary estimate of the cost of implementing the actions and was developed in accordance with NOAA Fisheries' guidelines for recovery plans. Costs are all in current dollars; they have not been adjusted for inflation or discounted to account for opportunity costs. Because these costs are preliminary and the specific set of actions that will be required to meet de-listing goals is not yet known, the sum of the costs presented here should not be presumed to be the cost of achieving de-listing. No attempt has been made to quantify either opportunity costs or economic benefits associated with proposed actions. While some actions described here will be implemented specifically to benefit steelhead and will be paid for by funds devoted to that purpose, many others will be implemented to achieve a wide range of benefits and will be paid for using an accordingly wide range of funding sources (e.g., floodplain enhancement projects that will improve habitat but also reduce infrastructure maintenance costs, improve flood protection for developable lands, and meet open space and recreation needs). Other actions (e.g., improving on-farm irrigation efficiency) will only occur when justified by direct benefits to the implementer, with benefits to fish as an incidental benefit. Section 5.1 described our attempt to address this complexity by assigning cost proportions, but to truly understand the economic impacts of specific actions requires a level of cost-benefit analysis not included in this plan.

5.5 Recovery Action Descriptions

This section provides detail on the 94 separate actions identified in this planning process. The action descriptions are given in a standardized format generated by the actions database maintained by the Yakima Basin Fish & Wildlife Recovery Board. This database will continue to be developed and will be linked with the implementation

schedules that will guide on-the-ground implementation and prioritization of recovery actions. Actions are presented in six groups: 1) Basinwide actions (16 total), which apply equally to all population areas, 2) Lower Mainstem Actions (9 total), which occur in the mainstem Yakima in areas shared by multiple populations (from the Columbia River to Roza Dam), and then 3) Naches (31 total), Satus (8 total), Toppenish (10 total) and Upper Yakima population area-specific actions (21 total), in that order. The sequence of actions does not indicate any priority; prioritization of actions will be specified in the implementation schedules under development. The references listed under limiting factors are the numbers of the related limiting factors in Tables 3.1 through 3.6.

Basinwide Action #1 **Modify reservoir operations to improve out-migration flows**

Key Partners:
Bureau of Reclamation

Affected MSAs:
All Spawning Areas

Focal Area: Mainstem Yakima and Naches Rivers **Implementation Likelihood:** Moderate

Time to Implement: 0-3 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions
Improve flow conditions
Improve flow conditions

Limiting Factors:
BW1,2,3

Cost Derivation: Operational change; no specific cost identified.

Total Cost: **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:**

Sufficient spring outmigration flows are essential for steelhead survival. Low spring flows increase smolt travel times and exposure to high temperatures and predators in the mainstem Yakima. In spring, BOR reservoir operations balance the need to refill storage with flood control. Flood control rule curves call for maintaining reservoirs at less than full levels in the early spring to provide capacity capture rapid runoff that would otherwise cause flooding. Later in spring, outflows are minimized to ensure refilling of reservoirs. This reduction in flows typically coincides with the smolt out-migration period. BOR has committed to studying alteration of rule curves themselves and is already altering operations to fill reservoirs sooner and spill in spring; other options include making releases during the outmigration period based on runoff predicitions, rather than spilling after reservoirs fill, and managing pulse flows. Evaluating the effects of changes in reservoir operations on water supply, flood hazard, and ecological functions should be facilitated by the work underway through the Storage Study. The potential of these changes to return the river to a more normative hydrograph without significantly impacting water supplies should be evaluated. Changes in spring/early summer reservoir operations may increase frequency of short-term overbank flooding, but would decrease the extent of long duration high water events, decreasing flood hazard, and increasing channel stability. Increased cottonwood regeneration and reductions in aquatic plant densities in the lower river are other potential benefits.

Basinwide Action #2 **Adequately screen all water diversions**

Key Partners:

Yakima Tributary Access and Habitat Program
Yakama Reservation Watersheds Project
Irrigation Districts
Individual irrigators
Conservation Districts
Bureau of Reclamation
Washington Department of Fish & Wildlife
Bonneville Power Administration

Affected MSAs:

All Spawning Areas

Focal Area: Basinwide **Implementation Likelihood:** High

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**

Time to Benefit: 0-3 years Restore unimpeded fish passage BW3

Cost Derivation: $300,000/year for 15 years based on current efforts.

Total Cost: $4,500,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $2,250,000

In the 1980s and 1990s, WDFW and the BOR updated fish screens on the larger diversions in the basin. These screens need ongoing maintenance and upgrading. Smaller diversions are being screened via the WDFW screen shop and the YTAHP program. Many smaller surface water and pump diversions need screening throughout the basin. Programs for these actions are in place, but limited by funding. Existing screens need to be operated and updated in a manner that ensures that they meet current criteria. Where fish are present in canals, fish salvage operations should continue. Entrainment in unscreened diversions is an issue for kelts as well as juveniles.

Basinwide Action #3 **Increase on-farm irrigation efficiency**

Key Partners:
- Irrigation Districts
- Department of Ecology
- Bureau of Reclamation
- Individual irrigators
- USDA Natural Resource Conservation Service
- Conservation Districts

Affected MSAs:
All Spawning Areas

Focal Area: Irrigated lands throughout the basin **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 0-3 years

Strategies:
Improve flow conditions
Improve water quality

Limiting Factors:
BW1,2

Cost Derivation: Work on 30% of 474,000 irrigated acres at a cost of $3,500/acre.

Total Cost: $497,700,000 **Fisheries:** 25% **Steelhead:** 50% **Steelhead Cost:** $62,212,500

Increases in on-farm irrigation efficiency can reduce the amount of water diverted from the river and reduce return flows and associated water quality issues. Benefits often also include increased agricultural productivity and reduced labor needs. Significant improvements have been made in recent decades by individual irrigators and NRCS, conservation districts, WSU extension and other programs. These efforts should be continued and expanded. Programs should ensure that reductions in on-farm water use can be tracked and utilized in a manner that directly contributes to instream flows at key locations and times (see actions that identify priority areas for flow improvement).

Basinwide Action #4 **Increase irrigation water delivery efficiency**

Key Partners:
- Bureau of Reclamation
- Irrigation Districts
- Department of Ecology
- Bureau of Reclamation
- Washington Department of Agriculture

Affected MSAs:
All Spawning Areas

Focal Area: Irrigation systems throughout the basin **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 0-3 years

Strategies:
Improve flow conditions

Limiting Factors:
BW1,2

Cost Derivation: Specific costs for high priority systems listed under specific actions.

Total Cost: **Fisheries:** 30% **Steelhead:** 50% **Steelhead Cost:**

Many of the irrigation systems in the basin could be upgraded. Where older systems have been converted to pressurized systems (e.g. the Yakima-Tieton) water consumption has been reduced, crop production has become more efficient, and susceptibility to drought has decreased. Even with increased irrigation assessments to maintain new systems, total cost of irrigation water has been reduced via reduced power demand and on-farm pumping. Delivery efficiency should be broadly promoted throughout the basin to reduce overall water demand and increase flexibility in reservoir operations. Power conservation programs, such as BPA's, should be used to support system improvements. Fisheries benefits are greatest where low flows are limiting during irrigation season; specific actions that address these areas are listed separately.

Basinwide Action #5 **Utilize Trust Water Rights Program to improve instream flows**

Key Partners:
Department of Ecology Water Trust Program
Washington Department of Fish & Wildlife
Bureau of Reclamation
Water Trust & Conservancies

Affected MSAs:
All Spawning Areas

Focal Area: Basinwide as opportunities arise **Implementation Likelihood:** Moderate

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**
Time to Benefit: 0-3 years Improve flow conditions BW1,2

Cost Derivation: $200,000/year plus 1 FTE & expenses at $75,000/year for 15 years.

Total Cost: $4,125,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $1,546,875

The Department of Ecology, BOR, Washington Water Trust, Washington Rivers Conservancy, Columbia Basin Water Transactions Program, and others have developed programs to lease and purchase water rights for instream use. Use of these programs could be significantly enhanced through education and outreach. This action is associated with the need for better water rights enforcement to ensure that once water is put into trust, it remains in-stream and is not diverted by down stream users. Benefits will be greatest in specific tributary locations; these are identified as separate actions in this plan.

Basinwide Action #6 **Continue kelt reconditioning**

Key Partners:
Columbia River Inter-Tribal Fisheries Commission
Yakima Klickitat Fisheries Project

Affected MSAs:
All Spawning Areas

Focal Area: Prosser Hatchery Facility **Implementation Likelihood:** High

Time to Implement: Ongoing **Strategies:** **Limiting Factors:**
Time to Benefit: 0-3 years Promote repeat spawning of kelts BW3,8

Cost Derivation: Existing program cost of $446,000/year (1/3 of BPA# 200306200 & 2/3 of BPA #200001700 as Yakima basin portion plus $50,000/yr YKFP contributions) for 15 years.

Total Cost: $6,690,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $6,690,000

The Yakima kelt reconditioning program directly increases the abundance of spawning adult steelhead with a relatively low risk of altering population characteristics. The kelt reconditioning program could play a role in reintroduction of populations to newly re-opened suitable habitats and in directed efforts to increase the numbers of spawning adults in specific steelhead populations in the subbasin. Monitoring of kelt reproductive success and genetic impacts should be expanded to ensure the kelt program is successful contributing to meeting recovery goals.

Basinwide Action #7 **Use artificial production techniques to restore steelhead to underutilized habitats**

Key Partners:
National Marine Fisheries Service
Yakama Nation
Washington Department of Fish & Wildlife
Yakima Klickitat Fisheries Project

Affected MSAs:
All Naches
All Upper Yakima

Focal Area: Targeted spawning areas in Naches and Upper Yakima Populations

Implementation Likelihood: Moderate

Time to Implement: 6-10 years

Time to Benefit: 6-10 years

Strategies:
Use small-scale supplementation

Limiting Factors:
BW8

Cost Derivation: $500,000 startup costs plus $200,000/year for 15 years based on use/expansion of existing facilities.

Total Cost: $3,500,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $3,500,000

Small-scale targeted supplementation that is designed to enhance steelhead VSP parameters may play an important role in accelerating recovery of the Upper Yakima and Naches populations. Focal areas would be watersheds with good habitat conditions where steelhead are not present or severely reduced due to historic passage barriers that have been or are being removed. Leading candidates include Cowiche, Manashtash, and Taneum watersheds. If passage into Naneum Creek and above Cle Elum and/or Bumping Dam is secured, these areas would also be strong candidates. Metrics should be developed to evaluate desired recolonization rates and population characteristics and the range of cultural actions that would be appropriate if these rates or populations characteristics are not met. The rate of colonization, productivity, life-history form (anadromous versus resident), and genetic structure of new populations should be closely monitored. The Yakima-Klickitat Fisheries Program is currently developing a Master Plan that will assess supplementation options.

Basinwide Action #8 **Continue coho, sockeye and summer Chinook reintroduction efforts**

Key Partners:
Yakima Klickitat Fisheries Project

Affected MSAs:
All Spawning Areas

Focal Area: Basinwide

Implementation Likelihood: High

Time to Implement: Ongoing

Time to Benefit: 6-10 years

Strategies:
Enhance upstream nutrient supplies

Limiting Factors:
BW9

Cost Derivation: Costs not directly attributable to steelhead recovery.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

The Yakima/Klickitat Fisheries Project is currently working to reintroduce coho to the subbasin and is evaluating the possibility of reintroducing sockeye and summer Chinook. These efforts have the potential to benefit steelhead by increasing the flow of ocean-derived nutrients into rearing areas in the Yakima Basin. Possibilities for competetive interactions also exist and should continue to be monitored by YKFP.

Basinwide Action #9 **Maintain a local policy and informational entity for steelhead recovery**

Key Partners:
Yakima Basin Fish & Wildlife Recovery Board

Affected MSAs:
All Spawning Areas

Focal Area: Basinwide

Implementation Likelihood: High

Time to Implement: Ongoing

Strategies:

Limiting Factors:

Time to Benefit: 0-3 years

Cost Derivation: $200,000/year over 15 years for steelhead portion.

Total Cost: $3,000,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $3,000,000

The Yakima Basin Fish & Widllife Recovery Board was established in 2006 to act as the regional recovery organization for the Yakima Basin under the State of Washington's salmon recovery framework. The Board plays an important role in 1) updating the local and federal steelhead recovery plans, 2) coordinating recovery actions both in the basin and with other recovery entities in the Mid-Columbia steelhead DPS, 3) tracking and reporting on the status of recovery efforts, and 4) building local and regional support for recovery efforts.

Basinwide Action #10 **Promote land and resource use decisions that protect and enhance fisheries resource values**

Key Partners:
Natural Resource Management Agencies
Local governments

Affected MSAs:
All Spawning Areas

Focal Area: Basinwide

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Strategies:
Protect existing functional habitat

Limiting Factors:
All

Time to Benefit: 0-3 years

Cost Derivation: Costs not directly attributable to steelhead recovery.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

Existing regulations and management programs that govern natural resource use need to be implemented in a manner that protects steelhead habitat and the upland and watershed functions that sustain it. These actions need to be coordinated with efforts to protect open space, wildlife habitat, and working landscapes; reduce flood damage; and support development that enhances the quality of life of local communities and meets the needs of private landowners. This plan identifies a number of specific non-regulatory protection actions that should be coordinated with ongoing work to build an effective and balanced system of land use management and zoning.

Basinwide Action #11 **Restore beaver populations**

Key Partners:
- Yakama Reservation Watersheds Project
- Local governments
- Washington Department of Fish & Wildlife

Affected MSAs:
- All Spawning Areas

Focal Area: Basinwide

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Time to Benefit: 3-10 years

Strategies:	Limiting Factors:
Restore floodplain connectivity/function	BW10
Restore channel structure/complexity	

Cost Derivation: Policy aspect not costed; Relocation & habitat management priced at $150,000/year for 15 years.

Total Cost: $2,250,000 **Fisheries:** 50% **Steelhead:** 75% **Steelhead Cost:** $843,750

Beaver played an important role in the pre-European hydrology of the Yakima Basin. Beaver dams and associated meadows can provide complex habitat and increase floodplain storage and the volume and quality of stream baseflows. Where beaver presence is compatible with land uses, it should be encouraged, via reductions in trapping and development of food sources (e.g. riparian plantings). Beaver dams that are potential nusiances can be managed to reduce flood risks or beavers can be relocated to more appropriate locations.

Basinwide Action #12 **Improve recruitment of cottonwoods**

Key Partners:
- Bureau of Reclamation
- USDA Natural Resource Conservation Service
- Private landowners and lessees
- Regional Fisheries Enhancement Group or other volunteer groups
- Conservation Districts
- Local governments
- Washington Department of Fish & Wildlife

Affected MSAs:
- All Spawning Areas

Focal Area: Floodplain reaches of the mainstem Yakima and Naches Rivers

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Time to Benefit: 6-10 years

Strategies:	Limiting Factors:
Restore riparian condition/future LWD	BW2

Cost Derivation: Undetermined.

Total Cost: **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:**

Natural black cottonwood germination generally requires overbank flow in late spring when seeds are dispersing and then a gradual reduction in flows as seedlings establish. This requirement is often at odds with current river operations. The regulated hydrograph could be altered in some years to increase the cottonwood regeneration rate in some reaches; identifying how to do so will require additional analysis. Many floodplain reaches have been heavily grazed and cottonwood regeneration has occurred in places where grazing pressure is relaxed, even under current flow regimes. This highlights the value of ongoing efforts to improve grazing management in riparian areas and floodplains. In the short term, planting programs for cottonwood, especially in the Wapato Reach, would benefit salmonids and the ecosystem as a whole.

Basinwide Action #13 **Address forest health issues**

Key Partners:
US Forest Service
Washington Department of Natural Resources
Private landowners
Bureau of Indian Affairs, Yakama Agency

Affected MSAs:
All Spawning Areas

Focal Area: Forested areas throughout Yakima Basin

Implementation Likelihood: Moderate

Time to Implement: Expand ongoing

Time to Benefit: 6-10 years

Strategies:
Restore riparian condition/future LWD
Improve upland watershed conditions

Limiting Factors:
BW4

Cost Derivation: Costs not directly attributable to steelhead recovery.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

The condition of forest stands directly affects watershed processes, and current increases in disease, pest and fire damage all threaten steelhead habitat. The U.S. Forest Service, the Bureau of Indian Affairs (which manages forests on the Yakama Reservation) and the Washington Department of Natural Resources all have programs to address forest health issues, but the need for treatment greatly exceeds the resources available to perform these tasks. Local interests such as the Yakima Basin Fish & Widllife Recovery Board, the Joint Board of Irrigators, Chambers of Commerce, the Farm Bureau, and federal agencies such as NOAA Fisheries, the BOR and BPA should make federal, state and local decision makers aware of the central role that healthy forests play in fish and wildlife conservation, cultural and recreational activities, management of the public and private water supplies and the health of the entire subbasin economy.

Basinwide Action #14 **Maintain and enforce in-basin fisheries regulations that protect steelhead**

Key Partners:
Washington Department of Fish & Wildlife
Yakama Nation

Affected MSAs:
All Spawning Areas

Focal Area: Basinwide

Implementation Likelihood: High

Time to Implement: Ongoing

Time to Benefit: 0-3 years

Strategies:
Maintain protective fishing regulations

Limiting Factors:
BW6,7

Cost Derivation: Policy action & use of existing enforcement capacity; no new cost charged to recovery.

Total Cost: **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:**

There is no directed recreational steelhead fishing allowed in the basin, and other fisheries are regulated to minimize impacts on steelhead. WDFW and the Yakama Nation should maintain protective regulations and ensure that they are adequately enforced.

Basinwide Action #15 **Evaluate and implement nutrient enhancement in steelhead streams**

Key Partners:
Yakima Klickitat Fisheries Project

Affected MSAs:
All Naches
All Upper Yakima

Focal Area: Selected tributary subwatersheds **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Enhance upstream nutrient supplies BW9

Cost Derivation: $0.50 (0.35/ft plus 0.15/ft program overhead based on NOAA fisheries estimates) per foot per year for 5 five mile reaches for 15 years.

Total Cost: $198,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $148,500

Historically, higher salmon runs transported significantly more oceanic-derived nutrients to Yakima Basin headwaters. There is interest in launching pilot nutrient enhancement projects in selected tributaries using salmon carcasses and/or carcass analogues. Potential sites include Taneum Creek and the Little Naches River, where carcass placement would occur following large woody debris enhancement (to facilitate retention of carcasses in headwaters). Nutrient enhancement should be coordinated with monitoring of steelhead response.

Basinwide Action #16 **Explore fisheries management options that reduce predation**

Key Partners:
Washington Department of Fish & Wildlife

Affected MSAs:
All Spawning Areas

Focal Area: mainstem Yakima River **Implementation Likelihood:** Moderate

Time to Implement: 0-3 years **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Maintain protective fishing regulations LM9

Cost Derivation: Policy decisions without specific cost to implement.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

Management of existing recreational fisheries for species that prey on steelhead could be implemented in a manner that reduces predation on steelhead, particularly during the outmigration of smolts. Changing recreational fishing rules for bass and catfish in the lower river to reduce number and/or change age structures so as to reduce predation on salmonids and establishing a pikeminnow bounty program have been identified as possible actions. Any efforts to adjust fisheries to reduce predation should be coordinated with ongoing monitoring designed to evaluate the impacts of these adjustments.

Lower Mainstem Action #1 **Increase flows in Chandler bypass reach to improve juvenile out-migration conditions**

Key Partners:
Bureau of Reclamation

Affected MSAs:
All Spawning Areas

Focal Area: Yakima mainstem below Prosser Dam **Implementation Likelihood:** Moderate

Time to Implement: 0-3 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions

Limiting Factors:
LM1

Cost Derivation: No cost to implement, but lost revenue due to reduced power sales (amount not specified at this time).

Total Cost: **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:**

Flows diverted to run the Chandler power plant reduce flows in the Yakima River from Prosser Dam to the powerplant return 12 miles downstream. During the spring, BOR currently reduces generation at the Chandler plant whenever flows would otherwise drop below the 1000 cfs subordination target during the spring. Increasing this minimum flow level when steelhead smolts are moving through the lower Yakima would improve passage conditions for smolts at Chandler Dam and in the bypass reach downstream. It would also reduce the proportion of juvenile entrainment in the Chandler powerhouse diversion and thereby reduce mortality rates in the Chandler canal and at the Chandler outfall. BOR has not committed to this action at this time; implementation would be facilitated by proposed changes to the KID irrigation system.

Lower Mainstem Action #2 **Improve flows below Parker through irrigation system improvements**

Key Partners:
Bureau of Reclamation
Roza-Sunnyside Board of Joint Control
Irrigation Districts
Bureau of Reclamation
BIA/Wapato Irrigation Project

Affected MSAs:
All Spawning Areas

Focal Area: Irrigation Districts in lower Yakima Valley **Implementation Likelihood:** Moderate

Time to Implement: > 10 years
Time to Benefit: 10-25 years

Strategies:
Improve flow conditions

Limiting Factors:
LM2,4,5

Cost Derivation: Roza ID, $40 million; Benton ID, $16 million; SVID, $50 million; KID, $35 million; WIP, $150 million; all very preliminary figures.

Total Cost: $291,000,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $72,750,000

The Sunnyside Irrigation District is nearing completion of a canal improvement project that will result in the dedication of about 20,000 acre/ft of water to instream use. The Wapato Irrigation Project is working with YRBWEP to move diversions for the Satus diversion from Wapato Dam to a new pump station near Granger, which would leave the water to be diverted instream for an additional 25 miles. The Kennewick Irrigation District is working with YRBWEP on several proposals to move some or all of their diversions downstream, potentially as far as the Columbia mainstem, and the Benton Irrigation District has also proposed moving diversions downstream. These proposal (and similar future proposals) would result in significant improvements in mainstem flows during the irrigation season while also resulting in improved water delivery for irrigators.

Lower Mainstem Action #3 Reconfigure infrastructure to improve smolt survival rates

Key Partners:
Bureau of Reclamation
Irrigation Districts

Affected MSAs:
All Spawning Areas

Focal Area: Chandler outfall, Wanawish/Horn Rapids Dam, WIP and SVID bypasses

Implementation Likelihood: High

Time to Implement: 0-3 years

Time to Benefit: 3-10 years

Strategies:
Change structures to reduce predation

Limiting Factors:
LM6,14,15,16

Cost Derivation: BOR cost estimate for outfall structure & a grade control in the river below the Chandler outfall.

Total Cost: $500,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $250,000

The current configuration of the Chandler juvenile bypass outfall and the condition of fish as they exit the bypass result in high concentrations of avian and aquatic predators and high predation rates at that site. Migrating smolts may also be subject to physiological stress and mortality in the bypass system. A more diffuse outfall, improved instream passage routes, bird deterrents and/or provision of additional cover or safe recovery areas for juveniles that transit the bypass would improve survival. Other potential bypass reaches and predation hotspots that should be assessed include Wanawish (Horn Rapids) Dam and the WIP and SVID screen bypass outfalls.

Lower Mainstem Action #5 Improve hydrograph through artificial storage and/or Columbia River water transfer

Key Partners:
Bureau of Reclamation
Department of Ecology

Affected MSAs:
All Spawning Areas

Focal Area: Lower basin (Parker and below)

Implementation Likelihood: Moderate

Time to Implement: > 10 years

Time to Benefit: 10-25 years

Strategies:
Improve flow conditions

Limiting Factors:
LM1,2

Cost Derivation: Cost as proposed is up to $6.5 billion; cost not attributed to steelhead recovery at this time.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

The Yakima Basin Storage Study is assessing proposals to increase water storage capacity through construction of the Black Rock and/or Wymer reservoirs and the possible transfer of water from the Columbia Basin to Yakima Basin irrigation use. As proposed, Black Rock Reservoir would eliminate the most severe effects of the flip-flop flow regime, improve flow and temperature in the Wapato reach, and potentially further delay the onset of lethal temperature regimes. There is still considerable uncertainty about the technical and economic feasibility of the Black Rock project; these questions should be resolved in the EIS to be released by the BOR in 2008. Any efforts to use water from outside the basin will need to ensure that imported water does not negatively affect homing of salmon and steelhead.

Lower Mainstem Action #6 **Restore mainstem and side channel habitats in the Union Gap reach**

Key Partners:

US Army Corps of Engineers
Yakima County
Bureau of Reclamation
Yakima Basin Side Channels Project

Affected MSAs:

All Naches
All Upper Yakima

Focal Area: Mainstem near City of Yakima

Implementation Likelihood: High

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:

Restore floodplain connectivity/function
Restore channel structure/complexity

Limiting Factors:

LM8,9,10,11

Cost Derivation: Based on preliminary estimate by Yakima County.

Total Cost: $13,500,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $3,375,000

The Union Gap reach of the Yakima River between Naches River and Wapato Dam is considered to have very high restoration potential. It is one of the only mainstem reaches that is not currently limited by severely altered flow and temperature regimes. YRBWEP has purchased large areas of floodplain habitat to the east of the river. The majority of this area is currently isolated by levees and passage barriers. Yakima County Flood Control Zone District is proposing to set back the levees in this reach to significantly increase the size of the active floodplain, including on the YRBWEP properties. WSDOT has constructed a new bridge at SR 24 which is much longer than the old bridge to allow the levee setback to proceed. Floodplain restoration work is being coordinated with Central Pre-mix's gravel mining operation.

Lower Mainstem Action #7 **Protect and restore mainstem and floodplain habitats below Sunnyside Dam**

Key Partners:

US Army Corps of Engineers
Yakima County
Bureau of Reclamation
Yakima Basin Side Channels Project
Land Conservancies
Yakama Nation Riparian/Wetlands Restoration Project

Affected MSAs:

All Spawning Areas

Focal Area: Floodplain reaches below Parker **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 0-3 years

Strategies:

Protect existing functional habitat
Restore floodplain connectivity/function
Restore channel structure/complexity
Restore riparian condition/future LWD

Limiting Factors:

LM1,3,7,8,9,11,14,15,16

Cost Derivation: 500 acres floodplain restoration (dike setback/reveg) at $10,000/acre, CREP/easement costs for 636 acres (5% of 1000' x 105 miles) at $3000/ac.

Total Cost: $6,908,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $2,590,500

Lower river conditions play a major role in migration timing for adults and survival of out-migrating smolts. Protecting and restorating mainstem and off-channel habitats (especially those that provide thermal refugia) is critical for these life stages. The best opportunities for restoration lie in the Wapato Reach (especially between the Toppenish/Satus confluences);additional opportunities exist in the very lower river at the Barker Ranch and adjacent to the City of West Richland. Work may include protecting habitat through acquisition, easements or cooperative agreements (including the CREP program), and activities like riparian plantings, reactivation of side channels, and winter irrigation to saturate floodplains. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Lower Mainstem Action #8 Reduce adult attraction to Sulphur Creek & Roza Wasteways

Key Partners:
Roza-Sunnyside Board of Joint Control
Irrigation Districts

Affected MSAs:
All Spawning Areas

Focal Area: Sulfur Drain (by Sunnyside)

Implementation Likelihood: High

Time to Implement: 0-3 years

Time to Benefit: 0-3 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:

Cost Derivation: $400,000 cost for barrier estimated by SVID; reducing flows costed in other actions. No cost available for Roza action.

Total Cost: $400,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $200,000

Sulphur Creek Wasteway (RM 61.0) receives return flows from the Roza and Sunnyside irrigation districts, and has attracted steelhead and salmon that can be stranded in the drain system when irrigation delivery ceases. To avoid this, fish are trapped and removed from the drain each fall. Even if stranding does not occur, passage delays associated with false attraction expose fish to predators and harassment by humans, and exposure to warm water can lessen their reproductive success. Measures to prevent or minimize such attraction are likely to increase steelhead spawning success. The Roza-Sunnyside Joint Board of Control is currently pursuing installation of a fish barrier in Sulfur Creek Wasteway 3/4 of a mile above the Yakima River [note: the fish barrier was completed in 2008 whiloe this plan was under review]. Reducing or eliminating return flows through the drain through improved irrigation system management is also a key part of long-term resolution of this issue (see Basinwide Action #3 and Lower Mainstem Action #2). Roza Wasteway near the City of Yakima is also known to have attract adult salmonids; Reclamation is currently looking at methods to improve the effectiveness of the barrier at the mouth of the wasteway.

Lower Mainstem Action #9 Improve quality of irrigation return flows

Key Partners:
BIA/Wapato Irrigation Project
Roza-Sunnyside Board of Joint Control
Department of Ecology
Irrigation Districts
Individual irrigators
USDA Natural Resource Conservation Service

Affected MSAs:
All Spawning Areas

Focal Area: Irrigation drains entering the lower Yakima River

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Time to Benefit: 0-3 years

Strategies:
Improve water quality

Limiting Factors:
LM4,5

Cost Derivation: Costs of Clean Water Act programs not attributed to specifically to steelhead recovery.

Total Cost: **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:**

In the last decade, the quality of return flows in the lower Yakima River has improved dramatically, with an ~90% decrease in turbidity due to improved irrigation management and implemention of the sediment TMDL for the lower Yakima River. The improved water quality is believed to be contributing to the rapid expansion of water star grass in the lower river. Work to continue water quality improvements should continue and should be accompanied by ongoing research to understand and respond to the ecological changes it is causing.

Naches Action #1 **Improve Wapatox Canal conveyance efficiency**

Key Partners:

Irrigation Districts
Bureau of Reclamation

Affected MSAs:

American
Bumping
Middle Naches
Rattlesnake
Tieton
Upper Naches

Focal Area: Wapatox by-pass reach of the lower Naches

Implementation Likelihood: Moderate

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:

Improve flow conditions

Limiting Factors:

N3,4

Cost Derivation: Based on preliminary discussions with BOR.

Total Cost: $3,000,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $1,500,000

BOR acquired the Wapatox power plant and diversion in 2002 in order to use the associated 300-450 cfs water right to augment instream flows in 7.4 miles of the lower Naches River. The Wapatox diversion also supplies 50 cfs of water to irrigators so the diversion remains active. The conveyance system was designed for 400 cfs and needs a minimum of approximately 130 cfs to provide sufficient head to run the system. This has reduced the amount of water BOR has been able to put to instream use. Improving the efficiency of the conveyance system would allow irrigators access to their full water rights while allowing all of the BOR's water right to be left instream. Consolidating the Wapatox and Naches-Selah diversions has been proposed, which would address this issue, increase instream flows between the Naches-Selah and Wapatox diversions, and reduce constraints on Bumping Reservoir operations.

Naches Action #2	**Improve water use efficiency and habitat in South Naches Irrigation District**

Key Partners:

Irrigation Districts
Bureau of Reclamation

Affected MSAs:

American
Bumping
Middle Naches
Rattlesnake
Tieton
Upper Naches

Focal Area: Lower mainstem Naches

Implementation Likelihood: Moderate

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:

Improve flow conditions

Limiting Factors:

N3,4

Cost Derivation: $1,000,000 estimate in Daily Journal of Commerce article (www.djc.com/news/en/11170266.html).

Total Cost: $1,000,000 **Fisheries:** 33% **Steelhead:** 50% **Steelhead Cost:** $165,000

The South Naches Irrigation District is currently examining means of improving efficiency of the irrigation system and habitat quality in the South Naches Channel. The South Naches Channel is composed of a mixture of natural and artificial channels that parallels the lower Naches for four miles and is used to conveys irrigation water. If appropriate habitat conditions and screening can be assured, the channel can provide increased steelhead rearing habitat. Water savings from efficiency improvements could be allocated to improve instream flows in the South Naches Channel and/or mainstem Naches.

Naches Action #3	**Improve water use efficiency in lower Naches irrrigation districts**

Key Partners:

Irrigation Districts
Bureau of Reclamation

Affected MSAs:

American
Bumping
Cowiche
Middle Naches
Rattlesnake
Tieton
Upper Naches

Focal Area: Lower mainstem Naches River **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years **Strategies:** **Limiting Factors:**

Time to Benefit: 3-10 years Improve flow conditions N3,4

Cost Derivation: $13 million City of Yakima system improvements; $5 million to move Fruitvale diversion to Nelson Dam;$5 million for other Districts.

Total Cost: $23,000,000 **Fisheries:** 33% **Steelhead:** 50% **Steelhead Cost:** $3,795,000

Irrigation system improvements that would increase instream flows have been proposed for the Naches-Selah Irrigation District, Naches Cowiche Canal Company, City of Yakima General Irrigation District (Nelson Dam), Fruitvale (City of Yakima), New Schanno Company, Fruitvale Schanno Company, Yakima Valley Canal Company (Congden Ditch), and Old Union Irrigation Company. These diversions reduce summer flows in steelhead rearing habitat between the diversion points and return flow locations. Increasing conveyance and on-farm efficiencies in these systems and using a portion of the water savings to increase instream flows will improve conditions for the Naches steelhead populations.

Naches Action #4 **Modify flip-flop flow regime**

Key Partners:

Bureau of Reclamation

Affected MSAs:

American
Bumping
Cowiche
Middle Naches
Rattlesnake
Tieton
Upper Naches

Focal Area: Tieton and Lower Naches Rivers **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions

Limiting Factors:
N2,3,4

Cost Derivation: Not estimated at this time; reservoir operation alternatives would have no direct cost, while major structural improvements would have high costs.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

The majority of the streams within the Naches watershed have a relatively unregulated flow regime that is nearer to natural conditions than the rest of the basin. However, flows in the Tieton and the Naches below the confluence with the Tieton are driven by Rimrock Reservoir operations. The flip-flop regime results in low flows in the Tieton through most of the irrigation season and then high (essentially bankfull) flows in the fall. Modifications to the flip-flop flow regime that improve habitat, flow, and temperature conditions for steelhead and other salmonid species in the Tieton and Lower Naches subbasin would have broad benefits for the Naches steelhead population. The negative effects of flip-flop could be addressed through alteration of reservoir operations, conservation, additional storage, or a combination of these and other measures. The Bureau of Reclamation, in collaboration with other subbasin resource managers and stakeholders, should determine if and how flip-flop can be modified to achieve these goals, make the necessary changes, and monitor habitat and fish population response.

Naches Action #5 **Restore lower Naches River floodplain**

Key Partners:

Lower Naches River Partnership Group
Yakima County
Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:

American
Bumping
Cowiche
Middle Naches
Rattlesnake
Tieton
Upper Naches

Focal Area: Lower Naches from Powerhouse Bridge area to confluence

Implementation Likelihood: High

Time to Implement: 6-10 years

Time to Benefit: 10-25 years

Strategies:

Restore floodplain connectivity/function

Limiting Factors:

N9,11

Cost Derivation: 1.2 mile dike removed & reconfigured at $5,000,000/mile.

Total Cost: $6,000,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $1,500,000

A cooperative project between the City of Yakima, Yakima County and WSDOT is seeking to restore floodplain functions in conjunction with planned capital projects for water conservation, elimination of irrigation diversions, reconstruction of Power House Road, and actions to protect US 12 from erosion. Wetland habitats with relatively cool water sources are found at several places along the river: across from Naches Wonderland, within and downstream of Eschbach Park, and the Buckskin Slough in the lower Naches. All of these areas could support increased rearing for salmonids and should be the focus of restoration activities. Proposals are described in the Upper Yakima Comprehensive Flood Management Plan.

Naches Action #6 **Improve sediment transport in lower Naches River**

Key Partners:

Irrigation Districts
Bureau of Reclamation
Yakima County
US Army Corps of Engineers

Affected MSAs:

American
Bumping
Cowiche
Middle Naches
Rattlesnake
Tieton
Upper Naches

Focal Area: Lower mainstem Naches **Implementation Likelihood:** Moderate

Time to Implement: > 10 years **Strategies:** **Limiting Factors:**

Time to Benefit: 10-25 years Restore channel structure/complexity N12

Cost Derivation: Diversion at Gleed (Naches Union) at $300,000, Naches-Cowiche diversion at $5,000,000, City of Yakima diversion at $100,00

Total Cost: $5,400,000 **Fisheries:** 33% **Steelhead:** 50% **Steelhead Cost:** $891,000

Confinement of the lower Naches has reduced sediment transport efficiency, causing aggradation upstream and channel incision or avulsion downstream. Where these facilities are located in the lower end of the alluvial valleys, such as near Eschbach Park/Yakima Water Treatment Plant, and at Rambler's Park/Cowiche (Nelson) Dam, their effects further reduce the amount of rearing habitat (i.e., side channels fed by groundwater return), which should be available in these locations. Improving sediment transport by modification of dam structure and levee reconfiguration will improve habitat availability over the long term. The Upper Yakima Comprehensive Flood Hazard Management Plan contains more detail regarding proposed reworking of Naches-Cowiche, Yakima Water Treatment Plant and Gleed (Naches Union) diversion dams to facilitate sediment movement (efforts will also benefit fish passage at the Naches-Cowiche diversion).

Naches Action #7 **Protect habitats in Naches River mainstem above Tieton confluence**

Key Partners:
- Private landowners
- Land Conservancies
- Washington Department of Fish & Wildlife
- Yakima County

Affected MSAs:
- American
- Bumping
- Middle Naches
- Rattlesnake
- Upper Naches

Focal Area: Nile and Oak Flats areas **Implementation Likelihood:** Moderate

Time to Implement: > 10 years **Time to Benefit:** 10-25 years

Strategies: Protect existing functional habitat

Limiting Factors: N10,14

Cost Derivation: Nile area side channels (60 acres @ $3,500/ac) & Oak Flats in progress ($600,000).

Total Cost: $816,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $204,000

Above the confluence with the Tieton, the Naches River is the least regulated of all Yakima Basin large rivers. Protecting functional habitat in the mainstem Naches and its floodplain above the Tieton confluence should be a priority and may involve a combination of acquisitions, conservation easements, and cooperative agreements. Priority areas include Oak Flats and the Nile area. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Naches Action #8 **Maintain, upgrade or abandon forest roads**

Key Partners:
- Private landowners
- Washington Department of Natural Resources
- US Forest Service
- Washington Department of Fish & Wildlife

Affected MSAs:
- All Naches
- Cowiche
- Upper Naches

Focal Area: Forested areas throughout population area **Implementation Likelihood:** Moderate

Time to Implement: Expand ongoing **Time to Benefit:** 3-10 years

Strategies:
- Improve water quality
- Improve upland watershed conditions

Limiting Factors: N14,15

Cost Derivation: 25 miles /year at $10,000/mile for fifteen years.

Total Cost: $3,750,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $937,500

Programs to address watershed impacts of forest roads exist for US Forest Service and WDNR lands, but are currently limited by funding/staffing and need to be expanded. The Forests and Fish Law applies on private lands. The Cowiche Creek and Little Naches watersheds should be a priority for development and implementation of Road Maintenance and Abandonment Plans under the Forests and Fish agreement. On Forest Service lands, a public scoping process, analysis, and a NEPA decision must be completed before a road can removed from the system.

Naches Action #9 **Provide passage at Bumping Lake Dam**

Key Partners:
Bureau of Reclamation

Affected MSAs:
Bumping

Focal Area: Upper Bumping River watershed **Implementation Likelihood:** Moderate

Time to Implement: 6-10 years
Time to Benefit: 10-25 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
N6

Cost Derivation: BOR has estimated costs of between $8.7 & $31 million; cost given here is for new spillway & fish ladder options.

Total Cost: $15,600,000 **Fisheries:** 100% **Steelhead:** 25% **Steelhead Cost:** $3,900,000

Bumping Lake is a natural glacial lake that supported a run of sockeye salmon. When a dam was constructed to raise the lake to store irrigation water, fish passage was not provided. Providing upstream and downstream fish passage at Bumping Lake would open up 6.6 miles of high quality habitat for steelhead. The BOR Fish Passage Study gives a detailed description (BOR 2005).

Naches Action #10 **Improve habitat in Lower Bumping**

Key Partners:
US Forest Service
Washington State Department of Transportation
Yakima County

Affected MSAs:
Bumping

Focal Area: Lower Bumping River **Implementation Likelihood:** High

Time to Implement: 0-3 years
Time to Benefit: 3-10 years

Strategies:
Restore floodplain connectivity/function
Restore channel structure/complexity

Limiting Factors:
N9,10,11

Cost Derivation: Based on USFS Naches Ranger District estimates.

Total Cost: $370,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $185,000

Redesign of the Bumping Road by the Federal Highways Administration is currently under way. The current design calls for road relocation and expansion to improve safety and reduce travel time. Habitat improvement work has been proposed as part of this road project, and would include: 1) strategically placing about 350 LWD pieces as engineered log jams and small clumps into wood deficient stream reaches (1, 3-4, 6) and along rip rap locations; and 2) Improving riparian conditions and streambank stability at 20-30 dispersed and developed camping areas (about 30 acres) in the Bumping River drainage through motor vehicle barriers, soil decompaction, road obliteration, campsite closures, replanting native vegetation, interpretive signing, and public education.

Naches Action #11 **Restore side channels and floodplain of Little Naches River**

Key Partners:
US Forest Service
Kittitas County
Yakama Nation

Affected MSAs:
Upper Naches

Focal Area: Little Naches mainstem **Implementation Likelihood:** Moderate

Time to Implement: 6-10 years **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Restore floodplain connectivity/function N9,10,11

Cost Derivation: Preliminary costs estimates by USFS & YN staff.

Total Cost: $950,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $356,250

After floods in the 1970s and 1980s, the main road accessing the Little Naches drainage was reconstructed as a levee and and over 6,000 tons of large wood debris were removed from the channel. Over time, this has led to aggradation and degredation of the main channel and isolation of the main channel from side channel and wetland habitats. Restoration of the Little Naches floodplain and reconfiguration of the road/levee system is a major undertaking and will require significant funding and technical support from the US Forest Service and/or the Federal Highway Administration via Kittitas County road department.

Naches Action #12 **Place large woody debris in Little Naches**

Key Partners:
US Forest Service
Yakama Nation
Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:
Upper Naches

Focal Area: Lower mainstem Little Naches **Implementation Likelihood:** Moderate

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**
Time to Benefit: 0-3 years Restore channel structure/complexity N9,10,11

Cost Derivation: 10 engineered log jams at $25,000 each.

Total Cost: $250,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $125,000

Lower reaches of the Little Naches lack large woody debris (LWD), in part due to large-scale wood removal efforts following flooding in the 1970s. This has contributed to downcutting of the stream channel, isolation or dewatering of off-channel habitats, channel instability and habitat simplification. LWD installation projects have been implemented in this watershed with the intent of improving fish habitat and reducing threats to developed campgrounds. Additional projects should be focus on improving fish habitat.

Naches Action #13 **Reduce dispersed recreation impacts in key tributaries**

Key Partners:
- Private landowners
- Regional Fisheries Enhancement Group or other volunteer groups
- US Forest Service
- Washington Department of Fish & Wildlife

Affected MSAs:
- Upper Naches
- Rattlesnake
- Middle Naches

Focal Area: Little Naches, American & Bumping rivers; Oak Creek

Implementation Likelihood: Moderate

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:
- Restore riparian condition/future LWD
- Improve water quality
- Improve upland watershed conditions

Limiting Factors: N20,21

Cost Derivation: $80,000/year for 4 months of 5 person crew & $50,000/year for equipment & supplies for 15 years.

Total Cost: $1,950,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $731,250

Impacts of recreational activities including dispersed camping and off-road vehicle (ORV) use can be significant in sensitive riparian areas. Over the last five years, the US Forest Service and partners have implemented successful programs to reduce these impacts. Coordinated education, enforcement, and on-the-ground restoration and protection efforts should be maintained and/or expanded in areas with high recreational use. The Little Naches will continue to be a focal area due to the high use by ORVs and the expected growth of this activity. These tasks will require additional funding for the US Forest Service and private forest landowners. ORV groups and the US Forest Service have developed a good working relationship, and the opportunity to partner with these organizations is high.

Naches Action #14 **Protect habitats in Little Naches River**

Key Partners:
- Private landowners
- Forest managers and partners
- Land Conservancies
- US Forest Service

Affected MSAs:
- Upper Naches

Focal Area: Private timberland in Little Naches drainage

Implementation Likelihood: Moderate

Time to Implement: > 10 years

Time to Benefit: 10-25 years

Strategies:
- Protect existing functional habitat

Limiting Factors: N10,14

Cost Derivation: 960 acres at $2,000/acre.

Total Cost: $1,920,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $1,080,000

The upper Little Naches passes through a checkerboard of US Forest Service and private timber company land. Ensuring long term protection of the fisheries habitat on private lands can be done through purchases, easements and cooperative agreements; acquisition of the 960 areas along the Little Naches could be integrated into significantly larger landscape-scale protection efforts in the Little Naches watershed. Land is currently protected through the Plum Creek Habitat Conservation Plan. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Naches Action #15 **Improve Nile Creek flows through improved irrigation management**

Key Partners:
Yakima County
Yakima Tributary Access and Habitat Program
North Yakima Conservation District

Affected MSAs:
Middle Naches

Focal Area: Lower Nile Creek

Implementation Likelihood: Moderate

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:
Improve flow conditions

Limiting Factors:
N3,4

Cost Derivation: $500/acre water conservation costs x 160 acres plus $120,000 infrastructure costs.

Total Cost: $200,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $50,000

Flows in lower Nile Creek are currently limited by irrigation water withdrawals. Improvements to irrigation infrastructure and potential transfer, lease or acquisition of water rights would increase summer and fall stream flows. Cost estimates for water conservation are generic estimates based on possible amounts; any actual amounts will be based on voluntary agreements negotiated with landowners.

Naches Action #16 **Improve channel conditions at the mouth of Nile Creek**

Key Partners:
Yakima County
Yakima Tributary Access and Habitat Program

Affected MSAs:
Middle Naches

Focal Area: Lower 1/4 mile of Nile Creek

Implementation Likelihood: High

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
N7

Cost Derivation: Based on existing designs.

Total Cost: $400,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $200,000

The box culvert across Nile Creek 1/4 mile above the Naches constricts the channel, resulting in sediment deposition and subsurface flows. The installation of a new bridge and channel reconstruction work would dramatically improve passage at this partial barrier. The current culvert is scheduled to be replaced in 2008; the new bridge will have a larger span that allows for improved sediment transport.

Naches Action #17 **Increase instream flows in lower Rattlesnake Creek**

Key Partners:
Department of Ecology
North Yakima Conservation District
Individual irrigators
Washington Department of Fish & Wildlife

Affected MSAs:
Rattlesnake

Focal Area: Lower Rattlesnake Creek

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Time to Benefit: 0-3 years

Strategies:
Improve flow conditions

Limiting Factors:
N3,4

Cost Derivation: Based on cost of $500/acre foot conservation or acquisition for 500 acre feet total.

Total Cost: $250,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $125,000

Irrigation diversions from Rattlesnake Creek can dewater the lower creek, where steelhead spawning has been documented. Improving irrigation and conveyance efficiencies, switching water users to shallow groundwater wells, leasing water rights and ensuring diversions are limited to legal rights can all be used to reduce diversions. Cost estimates for water conservation are generic estimates based on possible amounts; any actual amounts will be based on voluntary agreements negotiated with landowners.

Naches Action #18 **Improve sediment transport at Rattlesnake Creek/Naches confluence**

Key Partners:
Washington State Department of Transportation
Yakima County

Affected MSAs:
Rattlesnake

Focal Area: Confluence of Rattlesnake Creek and Naches River

Implementation Likelihood: Moderate

Time to Implement: > 10 years

Time to Benefit: 10-25 years

Strategies:
Restore floodplain connectivity/function

Limiting Factors:
N12

Cost Derivation: Excavation of 2,500 yds @ $10/yd; non-fish proportion is flood control.

Total Cost: $25,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $6,250

The unstable alluvial fan at the mouth of Rattlesnake Creek creates a pasage barrier in low-flow years. The configuration of the irrigation diversion, the Nile Road bridge, and levees on Rattlesnake Creek and the Naches River combine to reduce sediment transport. Improvement or reduction in the impact of the diversion upstream of the bridge and improvements to floodplain connectivity would improve sediment transport out of the Rattlesnake, improving habitat quality in both systems.

Naches Action #19 **Restore lower Cowiche Creek floodplain**

Key Partners:

Lower Naches River Partnership Group
Yakima County
Washington State Department of Transportation
Irrigation Districts
Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:

Cowiche

Focal Area: Lower Cowiche Creek and confluence with Naches River

Implementation Likelihood: High

Time to Implement: Ongoing

Time to Benefit: 10-25 years

Strategies:

Restore unimpeded fish passage
Restore floodplain connectivity/function

Limiting Factors:

N9,11

Cost Derivation: Acquisition of 32 acres of floodplain (350 ft x 3/4 mile) at $7,000/acre & movement of 30,000 cubic yard of dike materials at $10/yard.

Total Cost: $524,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $294,750

The lower end of Cowiche Creek has been confined by dikes and has been checked up in order to convey Naches River irrigation water (a potential source of false attraction). This action involves seperating delivery of Naches River water from Cowiche Creek, removing the check-structure and associated high-maintenance fish ladder, pulling back and/or removing the levees and improving riparian habitats. Associated infrastructure changes for the City of Yakima (Fruitvale) irrigation diversion are included under Naches Action #3. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Naches Action #20 **Protect Cowiche Creek watershed from increasing development pressure**

Key Partners:

Washington Department of Fish & Wildlife
Yakima (City) Habitat Improvement Project
Yakima County
North Yakima Conservation District
Private landowners
Land Conservancies

Affected MSAs:

Cowiche

Focal Area: Cowiche Creek watershed

Implementation Likelihood: High

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:

Protect existing functional habitat
Improve upland watershed conditions

Limiting Factors:

N9,10,11

Cost Derivation: Purchase of 360 acres of riparian corridor easement at $600/acre & 6 sections (3840 acres) at $800/ac (mix of easement & acquisition).

Total Cost: $3,288,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $1,644,000

Large parcels of private timber and rangelands in the upper Cowiche Creek watershed and smaller parcels lower in the watershed are all subject to increased development pressure. A mix of conservation easements, land purchases and cooperative agreements should be pursued to ensure that fish habitat and associated uplands are not negatively impacted. The area should be maintained in very low density zoning and regulation of road standards and wildland/urban interface standards for fire protection. This action overlaps with ongoing open space/wildlife habitat protection efforts. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Naches Action #21 **Reduce irrigation diversions from Cowiche Creek**

Key Partners:

Individual irrigators
North Yakima Conservation District
Washington Department of Fish & Wildlife
Irrigation Districts
Water Trust & Conservancies
Bureau of Reclamation

Affected MSAs:

Cowiche

Focal Area: South Fork and Mainstem Cowiche Creek

Implementation Likelihood: Moderate

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:

Improve flow conditions

Limiting Factors:

N3,4

Cost Derivation: Phase I currently being proposed by the Cowiche Water Users Association (7 cfs for $350,000). Phase II still to be defined.

Total Cost: $350,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $350,000

Irrigation diversions significantly reduce summer and falls flows in the lower 12 miles of the Cowiche Creek system. Irrigation system improvements that increase water use efficiencies, cooperative agreements with irrigators, and leases and purchase of water rights can all be used to reduce diversions. Much of the land irrigated from Cowiche Creek could potentially be served by the Yakima Tieton Irrigation District, and the possibility for agreements that provide irrigators with Yakima-Tieton water in exchange for leaving surface flows in Cowiche Creek should continue to be pursued.

Naches Action #22 **Improve riparian, floodplain, and temperature conditions in Cowiche Creek**

Key Partners:
- Washington Department of Fish & Wildlife
- Yakima Tributary Access and Habitat Program
- North Yakima Conservation District
- Private landowners and lessees
- Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:
- Cowiche

Focal Area: Mainstem and South Fork of Cowiche Creek; possibly Reynolds Creek

Implementation Likelihood: High

Time to Implement: > 10 years

Time to Benefit: 10-25 years

Strategies:	Limiting Factors:
Restore floodplain connectivity/function	N14,18,19
Restore channel structure/complexity	
Restore riparian condition/future LWD	

Cost Derivation: Riparian plantings along 10 miles at $15,000/mile, 3 miles of channel/floodplain restoration at $200,000/mile, instream LWD at $500 per installed piece at 50/mile for 5 miles & 6 miles fence at $10,000/mile.

Total Cost: $935,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $935,000

This action involves riparian planting, livestock fencing, grazing system improvements, channel/floodplain reconstruction, and large woody debris placement along numerous sites along Cowiche Creek. The middle reach will involve working with a number of smaller landowners, while the upper and canyon reaches are a mix of WDFW, Cowiche Canyon Conservancy, and large private lands that are suitable for large-scale restoration projects. Implementation of these actions should improve natural floodplain function, reduce flooding, and increase base flows, and water quality. The North Fork Cowiche historically comprised only a small proportion of the available habitat in the watershed and is not proposed for full restoration due to limited opportunities and high costs.

Naches Action #23 **Restore Oak Creek habitat**

Key Partners:
- US Forest Service
- Washington Department of Fish & Wildlife
- Yakima Tributary Access and Habitat Program

Affected MSAs:
- Tieton

Focal Area: Lower Oak Creek

Implementation Likelihood: High

Time to Implement: > 10 years

Time to Benefit: 10-25 years

Strategies:	Limiting Factors:
Restore channel structure/complexity	N14,17
Restore riparian condition/future LWD	

Cost Derivation: Revegetate 100 ft buffer each side of the creek for 3.5 miles for $30,000 & weed control of 3.5 miles for $2,500/mile for 3 years.

Total Cost: $56,250 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $42,188

Oak Creek is the only portion of the Tieton system that has been confirmed as supporting steelhead spawning. The entire watershed is owned by WDFW, US Forest Service and The Nature Conservancy. Much of the lower watershed (especially the riparian zone) has burned in recent wildfires and would benefit from replanting and weed control. Possibilities to improve instream and floodplain habitat and address road impacts should also be evaluated.

Naches Action #24 **Protect instream flow improvements in Ahtanum Creek**

Key Partners:
Ahtanum Irrigation District
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project

Affected MSAs:
Ahtanum

Focal Area: Mainstem Ahtanum Creek **Implementation Likelihood:** High

Time to Implement: Ongoing
Time to Benefit: 0-3 years

Strategies:
Improve flow conditions

Limiting Factors:
N3,4

Cost Derivation: 1 FTE & expenses at $75,000/year.

Total Cost: $1,125,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $843,750

Recent improvements in both summer and winter instream flows in Ahtanum Creek are due to agreements between the Yakama Nation, the Wapato Irrigation Project and Ahtanum Irrigation District. A network of wading discharge measurement transects and gauging stations are key to maintaining these agreements. Both the agreements and the supporting monitoring efforts should be continued.

Naches Action #25 **Develop off-channel storage in Ahtanum Creek**

Key Partners:
Ahtanum Irrigation District
BIA/Wapato Irrigation Project
Department of Ecology

Affected MSAs:
Ahtanum

Focal Area: Ahtanum, Bachelor and Hatton Creeks **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions

Limiting Factors:
N3,4

Cost Derivation: Cost as identified in preliminary feasibility study.

Total Cost: $45,000,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $11,250,000

The proposed Pine Hollow Reservoir would increasing the amount of water avaialble to meet and increase instream flows and meet irrigators' water needs. Associated irrigation system and habitat improvements would further increase benefits to steelhead by allowing full access to Bachelor and possibly Hatton Creeks. Implementation of the Pine Hollow project would require significant restructuring of complex water rights, including cooperation with the Yakama Nation, BIA/WIP, the Ahtanum Irrigation District, and private diverters. Funding for the project is not yet secured and environmental analyses have not been completed.

Naches Action #26 **Minimize irrigation conveyance loss in Ahtanum Creek**

Key Partners:
BIA/Wapato Irrigation Project

Affected MSAs:
Ahtanum

Focal Area: WIP Ahtanum Main Canal **Implementation Likelihood:** High

Time to Implement: 4-6 years **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Improve flow conditions N3,4

Cost Derivation: 2005 engineer's estimate was $116,305/mile for 5 miles. Multiplied by 1.2 for cost inflation since 2005.

Total Cost: $697,830 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $392,529

Areas of high seepage loss from the Wapato Irrigation Project's Ahtanum Main Canal have been identified and substantially increase the amount of water that has to be diverted to supply users near the end of the canal. Lining these sections of the canal would help in limiting diversions and increase instream flow.

Naches Action #27 **Ahtanum Creek floodplain and side channel restoration**

Key Partners:
Washington Department of Fish & Wildlife
Yakama Reservation Watersheds Project
Yakima County
North Yakima Conservation District

Affected MSAs:
Ahtanum

Focal Area: Ahtanum Creek and side channels **Implementation Likelihood:** Moderate

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Restore floodplain connectivity/function N10,11

Cost Derivation: Based on $90,000 cost of completed Herke side channel x 150% cost adjustment for 5 projects.

Total Cost: $675,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $379,688

There are several opportunities to reconnect side channels and enhance floodplain function in the Ahtanum Creek system, including the 7-mile spring creek through the airport, smaller channels upstream of major diversions, and, if agreements with irrigators can be developed (see Action #22), the Bachelor/Hatton system. Where there are opportunities to reconnect side channels, especially upstream from major diversions, both fish habitat and flood conveyance can be improved. Habitat restoration in lower Ahtanum will also benefit steelhead from other MSAs by providing rearing habitat adjacent to the Yakima River.

Naches Action #28 **Protect Ahtanum Creek riparian areas to lessen development impacts**

Key Partners:
- Washington Department of Fish & Wildlife
- Yakima County
- Yakama Nation
- Yakima (City) Habitat Improvement Project
- Land Conservancies

Affected MSAs:
- Ahtanum

Focal Area: Lower Ahtanum Creek

Implementation Likelihood: Moderate

Time to Implement: 0-3 years

Time to Benefit: 3-10 years

Strategies:
- Protect existing functional habitat

Limiting Factors:
- N9,10,11

Cost Derivation: 450 deeded riparian acres on south side at $8,000/acre; easements on 300 ft buffer for 50% of 10 miles (~180 acres) on northside at $8,000/acre.

Total Cost: $5,040,000 **Fisheries:** 50% **Steelhead:** 75% **Steelhead Cost:** $1,890,000

The lower part of Ahtanum Creek is affected by urbanization in Union Gap, Yakima, and nearby unincorporated areas, while the middle section is experiencing increased residential development. Residential/retirement/recreational development is also increasing in the upper watershed. Current opportunities to protect riparian areas and key floodplain parcels in lower Ahtanum Creek will disappear over time. Tools include land purchases and leases, conservation agreements, and cooperative agreements with landowners (e.g., incorporating protections into development plans). Development within Urban Growth Areas should be carefully planned to protect floodplains, riparian and instream resources, and private properties in this especially flood-prone watershed. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Naches Action #29 **Reduce livestock impacts on Ahtanum Creek riparian areas**

Key Partners:
- Washington Department of Fish & Wildlife
- Yakama Reservation Watersheds Project
- North Yakima Conservation District

Affected MSAs:
- Ahtanum

Focal Area: Ahtanum Creek and tributaries

Implementation Likelihood: High

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:
- Restore riparian condition/future LWD
- Improve upland watershed conditions

Limiting Factors:
- N18,19

Cost Derivation: Based on 20% of $250,000/year cost of Yakama Nation restoration crew; $20,000/year in riparian fencing materials; 5 stock water wells at $60,000 each; annual lease on 640 acres on reservation at $85/acre/yr for 15 years; 7 miles fencing at $10,000/mile; & 2 miles of riparian plantings at $15,000/mile on Northside.

Total Cost: $2,216,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $1,246,500

Improving the condition of Ahtanum Creek's riparian areas will help realize the maximum benefit from instream flow improvements. The Yakama Reservation Watersheds Program has been active on the south side of the creek, while the North Yakima Conservation District has worked extensively with landowners on the North side in its successful efforts to address screening and passage barriers. The Ahtanum Watershed Restoration EIS includes several specific actions.

Naches Action #30 **Improve winter flows below storage dams**

Key Partners:
Bureau of Reclamation

Affected MSAs:
Tieton
Bumping

Focal Area: Tieton, Bumping and Naches rivers below Rimrock and Bumping Lakes

Implementation Likelihood: Moderate

Time to Implement: 0-3 years

Time to Benefit: 0-3 years

Strategies:
Improve flow conditions

Limiting Factors:
N1

Cost Derivation: Operational change; no specific cost identified.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

Late fall/winter flows below Rimrock and Bumping reservoirs are maintained at low levels relative to the unregulated hydrograph, with occassional large releases made for flood control purposes. Effects on the Bumping River are minimal in most years, but the Tieton is significantly affected. Adjusting reservoir operations to increase winter base flows will improve overwintering habitat. The Bureau increased winter flow in the Tieton in 2008 (to a base of ~100-125 cfs vs earlier targets as low as 30cfs); this commitment should be continued.

Naches Action #31 **Restore side channels and floodplain of Upper Naches River**

Key Partners:
US Forest Service
Washington Department of Fish & Wildlife
Private landowners
Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:

Focal Area: Naches River between Tieton confluence and Little Naches

Implementation Likelihood: Moderate

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:
Restore floodplain connectivity/function
Restore channel structure/complexity

Limiting Factors:
N9,10,11

Cost Derivation: Preliminary cost estimates by US Forest Service staff.

Total Cost: $200,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $100,000

Several historic off channel habitats could be enhanced by increasing water flow into them for longer seasonal periods of the year. These off channel habitats are important rearing and refuge areas for juvenile salmonids. Engineered log jams or other instream hydrologic structures could regulate flows into these low gradient side channels.

Satus Action #1 **Reconnect Satus Creek floodplain**

Key Partners:

Yakama Nation Riparian/Wetlands Restoration Project
Washington State Department of Transportation
Yakama Reservation Watersheds Project

Affected MSAs:

Dry
Satus

Focal Area: Mainstem of Satus Creek (lower 8 miles and along Highway 97)

Implementation Likelihood: Moderate

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:

Restore floodplain connectivity/function

Limiting Factors:

S3,4,5

Cost Derivation: Construction of 50 check structure at $20,000 per structure; purchase of 320 acres floodplain at $4000/acre & $215/yr restoration/maintenance cost; & lease of 5000 acres (Satus Wildlife Area, Mule-Dry Confluence, Hwy 97 corridor) at $50/ac/yr lease plus $30/yr maintenance for 15 yrs. Estimate does not include WSDOT cost such as bridge replacement.

Total Cost: $9,312,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $5,238,000

Lower Satus Creek is entrenched and partly confined by dikes. It may not be possible to elevate the creek to the its original floodplain in this reach, but allowing it to meander at its present level, and introducing appropriate roughness features will restore some of the original channel complexity and floodplain functions. Impacts from US 97 farther uspstream are being addressed through a cooperative consultation process between the Yakama Nation and the WSDOT. Examples include the planned replacement of the US 97 crossing of Logy Creek near its confluence with Satus Creek (RM 23.7), which needs to include floodplain restoration at the previous crossing alignment as well as careful design of the replacement and reactivating the floodplain in the reach immediately downstream from the “High Bridge” (RM 32.4). US 97 also restricts the movement of bedload from tributary streams into Satus Creek at several crossings including Kusshi, Shinando, and a host of unnamed tributaries, contributing to incision of Satus Creek. There are also several large levees that could be removed to promote better stream/floodplain connectivity. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Satus Action #2 **Continue improving management of cattle and improve management of feral horses**

Key Partners:
Yakama Reservation Watersheds Project

Affected MSAs:
Dry
Satus

Focal Area: Entire Satus Creek Watershed **Implementation Likelihood:** Moderate

Time to Implement: Ongoing
Time to Benefit: 3-10 years

Strategies:
Restore riparian condition/future LWD
Improve upland watershed conditions

Limiting Factors:
S9,10

Cost Derivation: 20% of restoration crew cost of $250,000/yr plus materials to build & repair range, riparian, & meadow fencing at $10,000/yr plus lease of critical grazing units at $25,000/yr; all for 15 years & 10 stock water well installations at $60,000 each.

Total Cost: $1,875,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $937,500

Recent and ongoing improvements in the management of cattle grazing have reduced grazing impacts in the Satus Creek watershed. Impacts from wild horses are ongoing, and the Yakama Nation is developing a wild horse management plan for the Satus and Toppenish Creek watersheds which will focus on limiting riparian zone damage.

Satus Action #3 **Reroute North Drain to address return flow issues in lower Satus Creek**

Key Partners:
Bonneville Power Administration
Yakama Nation Riparian/Wetlands Restoration Project
US Fish & Wildlife Service
US Army Corps of Engineers
USDA
Yakama Reservation Watersheds Project

Affected MSAs:
Dry
Satus

Focal Area: Lower mainstem of Satus Creek **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions
Improve water quality

Limiting Factors:
S1

Cost Derivation: Cost of $3,000,000 based on estimates by US Army Corps of Engineers & Yakama Nation.

Total Cost: $3,000,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $1,125,000

Between 5 and 40 cfs of irrigation return flows from the Wapato Irrigation Project enter lower Satus Creek via the North Drain. Rerouting the North Drain into wetlands on the Satus Wildlife Area would reduce the quantity and increase the quality of return flows into Satus Creek. Initial plans have been developed in cooperation with the US Army Corps of Engineers.

Satus Action #4 **Improve Satus East and West Laterals to address return flow issues**

Key Partners:
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

Affected MSAs:
Dry
Satus

Focal Area: Lower mainstem of Satus Creek **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions
Improve water quality

Limiting Factors:
S1

Cost Derivation: $3,380,000 based on 2001 conservation plan (1998 costs).

Total Cost: $3,380,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $845,000

The Satus East and West Laterals empty into Satus Creek. Piping the Satus Area of the Wapato Irrigation Project will allow for better management of return flows to Satus Creek. This is one component of the Yakima River Basin Water Enhancement Program's conservation plan for the Wapato Irrigation District. The Secretary of Interior has approved the infrastructure portion of the WIP Priority Water Conservation Measures Plan and a 1990 authorization of $18 million is allocated to the project, but may need to be supplemented. Implementing the Conservation Measures Plan will also improve instream flow and water quality in the Yakima River (see Lower Mainstem Action #10).

Satus Action #5 **Remove BIA Satus Diversion Dam**

Key Partners:
Yakama Reservation Watersheds Project

Affected MSAs:
Dry
Satus

Focal Area: Lower mainstem of Satus Creek **Implementation Likelihood:** High

Time to Implement: 0-3 years
Time to Benefit: 0-3 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
S2

Cost Derivation: Preliminary engineering estimated at $90,000 & construction at $250,000.

Total Cost: $340,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $340,000

The Satus Diversion Dam is no longer in use. Its rudimetary fish ladder is prone to tampering by recreationists. Removing the existing concrete diversion dam and diversion canal headworks would improve stream channel habitat, eliminate a partial steelhead passage barrier and restore this reach of the creek to a more natural and productive condition.

Satus Action #6 **Restore passage in Shinando Creek at Highway 97 crossing**

Key Partners:
Washington State Department of Transportation
Yakama Reservation Watersheds Project

Affected MSAs:
Satus

Focal Area: Shinando Creek **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Restore unimpeded fish passage S6

Cost Derivation: The project presents challenges (hence the high cost estimate) but pipe boring techniques are improving, which may decrease cost below estimate.

Total Cost: $1,500,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $1,500,000

Fish access to the Shinando drainage is blocked by an impassable structure under Highway 97 that is under deep fill. Preliminary engineering indicates that it may be feasible to restore passage without removal of the fill.

Satus Action #7 **Improve, relocate, or close forest roads**

Key Partners:
Bureau of Indian Affairs, Yakama Agency
Yakama Reservation Watersheds Project

Affected MSAs:
Dry
Satus

Focal Area: Entire Satus Creek Watershed **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years **Strategies:** **Limiting Factors:**
Time to Benefit: 3-10 years Improve upland watershed conditions S7,8

Cost Derivation: 5 miles/yr of road reconstruction, upgrade, or abandonment at $10,000/mi x 15 yrs.

Total Cost: $750,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $375,000

Overall, forest roads have been built and maintained to a lower standard on the Yakama Reservation than on, for example, US Forest Service land. There is a need to continue and expand road closures, relocations and drainage improvements to reduce sediment and peak flows deliveries to creeks. The Yakama Reservation Watersheds Project and other tribal programs have assessed these needs and will coordinate a road improvement program with BIA, which manages reservation forestlands.

Satus Action #8 **Restore headwater meadows**

Key Partners:
Bureau of Indian Affairs, Yakama Agency
Yakama Reservation Watersheds Project

Affected MSAs:
Dry
Satus

Focal Area: Entire Satus Creek Watershed

Implementation Likelihood: High

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:
Improve flow conditions
Improve water quality

Limiting Factors:
S11

Cost Derivation: 10% of $250,000/yr cost for restoration crew plus $15,000/yr construction costs (most work will be hand work, but several locations will require machinery). Fencing is covered under Action #12. $200,000 is included for possible land purchases.

Total Cost: $800,000 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $600,000

Steelhead productivity in the Satus Creek watershed is hampered by rapid runoff and minimal summer streamflow. Some of this problem can be traced to headwater meadows that are dissected by gullies and no longer store runoff efficiently. The Yakama Reservation Watersheds Project has been refining headwater meadow restoration techniques and will coordinate further restoration efforts.

Toppenish Action #1 **Rehabilitate alluvial fan and downstream floodplain of Toppenish Creek**

Key Partners:
- BIA/Wapato Irrigation Project
- Yakama Nation Riparian/Wetlands Restoration Project
- Yakama Reservation Watersheds Project
- Bureau of Reclamation

Affected MSAs:
- Simcoe
- Toppenish

Focal Area: Lower mainstem of Toppenish Creek **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 3-10 years

Strategies:
Restore floodplain connectivity/function

Limiting Factors:
T5,7,9,10,11

Cost Derivation: On the alluvial fan, open 14 swale crossings at $150,000 each & breach/remove 0.5 miles of dike at 60,000 yards/mi & $10/yd. For the downstream floodplain, 10 miles of side channel reconnection & grade control at $150,000/mi, 20 miles of revegetation at $15,000/mi across 2 channels. Seepage study based on 0.5 FTE x $75,000 x 2 yr & $50,000 materials. Maintain 2,000 acreat $35/ac/yr for 15 years.

Total Cost: $5,675,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $2,837,500

The Yakama Nation plans to restore floodplain functions on the Toppenish Creek alluvial fan and along lower Toppenish Creek. This action builds on 1) BIA-funded rehabilitation of the lower canyon/upper fan reach of Toppenish Creek, 2) the acquisition and rehabilitation of riparian lands on lower Toppenish Creek funded by BPA and other entities, and 3) instream flow improvements mandated by the Yakama Nation below a BIA diversion. Funding for the Toppenish Creek Corridor Enhancement Plan is being pursued via YRBWEP and the continuation of existing funded restoration programs. This action should include studies of seepage loss in the alluvial fan reach of the creek to determine if agricultural drains or deep well pumping are contributing to the loss of instream flows and, if so, identify possible mitigation efforts.

Toppenish Action #2 **Elevate Marion Drain to restore Toppenish Creek flows and water quality**

Key Partners:
- BIA/Wapato Irrigation Project
- Yakama Reservation Watersheds Project
- Bureau of Reclamation

Affected MSAs:
- Simcoe
- Toppenish

Focal Area: Lower mainstem of Toppenish Creek **Implementation Likelihood:** Moderate

Time to Implement: 0-3 years
Time to Benefit: 3-10 years

Strategies:
Restore floodplain connectivity/function
Improve flow conditions

Limiting Factors:
T3,7

Cost Derivation: Yakama Nation Engineering preliminary estimate.

Total Cost: $2,000,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $1,125,000

Marion Drain runs parallel to Toppenish Creek for 18 miles, and is deeper than Toppenish Creek for most of its length. It intercepts groundwater that would otherwise reach Toppenish Creek. The drain is deeper than needed for agricultural drainage. Constructing grade controls to raise the water surface in the drain could improve water quantity and quality throughout a 25-mile reach of Toppenish Creek without reducing the drain's ability to meet agricultural needs.

Toppenish Action #3 **Replace undersized crossing culvert in Toppenish Creek**

Key Partners:
Yakama Reservation Watersheds Project
Private landowners

Affected MSAs:
Toppenish

Focal Area: Mainstem of Toppenish Creek above Simcoe Creek

Implementation Likelihood: High

Time to Implement: 0-3 years

Time to Benefit: 0-3 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
T12

Cost Derivation: Engineering for $40,000. Project construction estimates begin at $150,000 & could be significantly higher.

Total Cost: $230,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $230,000

In February 2006, Yakama Nation personnel found a farm crossing of Toppenish Creek just upstream from the Simcoe Creek confluence that appears to impede adult steelhead passage at moderately high streamflow of several hundred cfs. This structure should be removed or replaced to provide unimpeded fish passage; purchasing 139 acres (appraised at $660k) would make the crossing unnecessary and protect nearly a mile of Toppenish and Simcoe creeks.

Toppenish Action #4 **Complete passage and screening projects in Simcoe Creek**

Key Partners:
Yakama Reservation Watersheds Project
Individual irrigators

Affected MSAs:
Simcoe

Focal Area: Lower Simcoe Creek

Implementation Likelihood: Moderate

Time to Implement: Expand ongoing

Time to Benefit: 0-3 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
T6,12

Cost Derivation: Based on a cost of $20,000/cfs for previous screens in area.

Total Cost: $300,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $300,000

There are three remaining unscreened irrigation diversions on Simcoe Creek (South Fork, Hubbard and Smartlowit), with a total capacity of 15 cfs. Screening is complicated by the dynamic nature of the stream channel. A proposal to supply the Hubbard Diversion from the existing screened Hoptowit Diversion could not be implemented. Other options should be explored to lessen this cost.

Toppenish Action #5 **Further reduce diversions by improved water management.**

Key Partners:
Yakama Reservation Watersheds Project

Affected MSAs:
Simcoe
Toppenish

Focal Area: Lower Simcoe and Toppenish creeks **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions

Limiting Factors:
T12,18

Cost Derivation: Cost based on 1 FTE staff at 75,000/yr for 15 years & 10 stock water wells at $50,000 each.

Total Cost: $1,625,000 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $1,218,750

Efforts should be made to increase water use efficiencies, reducing diversions, and increasing instream flow. This could include additional wells to provide stock water during the low-flow period, replacing inefficient surface water delivery. A number of stock water wells are already in operation, which has allowed the Yakama Nation to limit diversions and increase instream flow. Cost includes staff time to monitor flow, calibrate gauges, work with irrigators to implement criteria, and improve water management for fisheries benefits.

Toppenish Action #6 **Remove irrigation spills and returns from Toppenish and Simcoe creeks**

Key Partners:
BIA/Wapato Irrigation Project
Yakama Reservation Watersheds Project
Bureau of Reclamation

Affected MSAs:
Toppenish
Simcoe

Focal Area: Lower Toppenish and Simcoe creeks **Implementation Likelihood:** Moderate

Time to Implement: 6-10 years
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions
Improve water quality

Limiting Factors:
N3,4,5

Cost Derivation: Yakama Nation Engineering preliminary estimate.

Total Cost: $3,750,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $2,109,375

The Wapato Irrigation Project (BIA) routes operational spills and sediment-laden return flows down Toppenish and Simcoe creeks to supply other areas of the project. Studies have been initiated by the Yakama Nation on the feasibility of separating these irrigation flows from the creek system. Elimination of return flow should be combined with efforts to restore groundwater seepage, currently intercepted by Marion Drain, back into Toppenish Creek (see Action #2).

Toppenish Action #7 **Continue leases, purchase, and management of riparian areas**

Key Partners:
- Yakama Nation Riparian/Wetlands Restoration Project
- Yakama Reservation Watersheds Project
- Bureau of Reclamation

Affected MSAs:
- Toppenish
- Simcoe

Focal Area: Lower Toppenish and Simcoe creeks **Implementation Likelihood:** High

Time to Implement: Ongoing
Time to Benefit: 3-10 years

Strategies:
- Protect existing functional habitat
- Restore riparian condition/future LWD

Limiting Factors:
- N8

Cost Derivation: Cost based on current program cost of $1,000,000/year for 15 years.

Total Cost: $15,000,000 **Fisheries:** 50% **Steelhead:** 75% **Steelhead Cost:** $5,625,000

Current efforts to protect riparian and floodplain lands via acquisition of land, easements, and Tribal trust leases need to continue in order to protect and restore lower Toppenish and Simcoe creek adult migration and holding areas and juvenile fall, winter, and spring rearing areas. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Toppenish Action #8 **Improve, relocate, or close forest roads**

Key Partners:
- Bureau of Indian Affairs, Yakama Agency
- Yakama Reservation Watersheds Project

Affected MSAs:
- Simcoe
- Toppenish

Focal Area: Entire Toppenish Creek Watershed **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years
Time to Benefit: 3-10 years

Strategies:
- Improve upland watershed conditions

Limiting Factors:
- N13,14

Cost Derivation: 5 miles/year of road reconstruction, upgrade, or abandonment at $10,000/mi for 15 yrs.

Total Cost: $750,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $375,000

Overall, forest roads have been built and maintained to a lower standard on the Yakama Reservation than on, for example, US Forest Service land. There is a need to continue and expand road closures, relocations, and drainage improvements to reduce sediment and peak flows deliveries to creeks. The Yakama Reservation Watersheds Project and other tribal programs have assessed these needs and will coordinate a road improvement program with BIA, which manages reservation forestlands.

Toppenish Action #9 **Continue improving management of cattle and improve management of feral horses**

Key Partners:
Yakama Reservation Watersheds Project

Affected MSAs:
Simcoe
Toppenish

Focal Area: Entire Toppenish Creek Watershed **Implementation Likelihood:** Moderate

Time to Implement: Ongoing
Time to Benefit: 3-10 years

Strategies:
Restore riparian condition/future LWD
Improve upland watershed conditions

Limiting Factors:
N15,16

Cost Derivation: 20% of restoration crew cost of $250,000/yr plus materials to build & repair range, riparian, & meadow fencing at $10,000/year; all for 15 years & 5 stock water well installations at $60,000 each.

Total Cost: $1,200,000 **Fisheries:** 50% **Steelhead:** 100% **Steelhead Cost:** $600,000

Recent and ongoing improvements in the management of cattle grazing have reduced impacts in the Toppenish Creek watershed. Impacts from wild horses are ongoing and the Yakama Nation is developing a wild horse management plan for the Satus and Toppenish Creek watersheds, which will focus on limiting riparian zone damage.

Toppenish Action #10 **Restore headwater meadows**

Key Partners:
Bureau of Indian Affairs, Yakama Agency
Yakama Reservation Watersheds Project

Affected MSAs:
Satus
Toppenish

Focal Area: Entire Toppenish Creek Watershed **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 3-10 years

Strategies:
Improve flow conditions
Improve water quality

Limiting Factors:
N17

Cost Derivation: 10% of $250,000/yr cost for restoration crew plus $15,000/yr construction costs (most work will be hand work, but several locations will require machinery). Fencing is covered under Action #9. $200,000 is included for possible land purchases.

Total Cost: $800,000 **Fisheries:** 75% **Steelhead:** 100% **Steelhead Cost:** $600,000

Steelhead productivity in the Toppenish Creek watershed is limited in large part by summer streamflow. Some of this problem can be traced to headwater meadows that are dissected by gullies and no longer store runoff efficiently. The Yakama Reservation Watersheds Project has been refining headwater meadow restoration techniques and will coordinate further restoration efforts.

Upper Yakima Action #1 **Redesign Roza Dam facilities to improve downstream smolt passage**

Key Partners:
Bureau of Reclamation

Affected MSAs:
All Upper Yakima

Focal Area: Roza Dam

Implementation Likelihood: High

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
U9

Cost Derivation: Price noted at BOR presentation at Yakima Basin Science & Management Conference in 2006.

Total Cost: $4,500,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $2,250,000

Roza Dam's spill gates currently hinder smolt outmigration unless "tucked" periodically to allow surface spill. When no surface spill occurs at Roza Dam, downstream migrating fish must either navigate through the fish screen bypass located in slackwater with poor attraction flows or sound deep to pass through a small slot near the bottom of the dam structure. The passage obstacle at Roza is thought to increase overall travel time for migrants, prolong exposure to predation in the dam pool, and physically harm passing fish. Proposed modifications would allow some surface spill to be maintained under all conditions. BOR has completed a preliminary design and is scheduled to begin construction in 2009. Gate modifications that allow for surface spill at lower flows should not be used to justify maintenance of insufficient instream flows below Roza (see Upper Yakima Action #2).

Upper Yakima Action #2 **Improve instream flows below Roza Dam**

Key Partners:
Bureau of Reclamation
Irrigation Districts

Affected MSAs:
All Upper Yakima

Focal Area: Mainstem Yakima River from below Roza to Yakima

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Time to Benefit: 0-3 years

Strategies:
Improve flow conditions

Limiting Factors:
U3

Cost Derivation: Cost of lost power under different scenarios are currently being calculated by BPA. Initial estimates for cost of tucking gates whenever flows during the spring allow are ~$160,000/yr.

Total Cost: $2,400,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $1,200,000

Water diversions used for power generation decrease flows in the Yakima River between Roza Dam and the powerplant outfall 15 miles downstream. Many fish biologists in the basin have recommended provisions of higher outmigration flows below Roza Dam to reduce downstream travel times and increase smolt survival. This requires developing biologically based instream flow targets for this reach for the smolt outmigration (April 1 to May 31st) and then reducing or eliminating power diversions at Roza when needed to meet recommended flows. The Bureau of Reclamation has not yet agreed to this action, and its implementation may have funding consequences for Reclamation and the Roza Irrigation District. The possibility of making up for this loss of revenue through a contract with BPA should be explored in conjunction with this action.

Upper Yakima Action #3 **Modify flip-flop flow regime**

Key Partners:	**Affected MSAs:**
Bureau of Reclamation	All Upper Yakima

Focal Area: **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years	**Strategies:**	**Limiting Factors:**
Time to Benefit: 3-10 years	Improve flow conditions	U1,6

Cost Derivation: Not estimated at this time; reservoir operation alternatives would have no direct cost, while major structural improvements would have high costs.

Total Cost:	**Fisheries:**	**Steelhead:**	**Steelhead Cost:**

The flip-flop flow regime results in high flows in the mainstem Yakima throughout most of the summer as Lake Cle Elum serves as the primary source for lower valley irrigation, and then a significant reduction in flows in the fall as BOR shifts to Rimrock Reservoir. The flip-flop regime was devised in response to a court order to protect spring chinook redds in the upper Yakima and Cle Elum rivers, but it is hypothesized to be significantly reducing rearing capacity for juvenile salmonids. Modifications to the flip-flop flow regime that improve habitat, flow, and temperature conditions for steelhead and other salmonid species in the regulated reaches of the subbasin would have broad benefits. The negative effects of flip-flop could be addressed through alteration of reservoir operations, conservation, additional storage, or a combination of these, and other measures. The Bureau of Reclamation, in collaboration with other subbasin resource managers and stakeholders, should determine if and how flip-flop can be modified to achieve these goals, make the necessary changes, and monitor habitat and fish population response.

Upper Yakima Action #4 **Improve instream flows in Swauk Creek and Teanaway watersheds**

Key Partners:

- Bureau of Reclamation
- Department of Ecology
- Individual irrigators
- Kittitas County Conservation District
- Kittitas Conservation Trust
- Water Trust & Conservancies
- Bonneville Power Administration
- Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:

- Swauk
- North Teanaway
- West Teanaway

Focal Area: Teanaway River, Swauk Creek and tributaries

Implementation Likelihood: Moderate

Time to Implement: Ongoing

Time to Benefit: 0-3 years

Strategies:

Improve flow conditions

Limiting Factors:

U4,5

Cost Derivation: Costs depend on options pursued & could be made part of development conditions; projected cost based on acquisition of 1000 acre feet of water at $500/af.

Total Cost: $500,000 **Fisheries:** 100% **Steelhead:** 100% **Steelhead Cost:** $500,000

The Teanaway River and its forks and Swauk Creek and its tributaries have summer/fall stream flows that are significantly reduced by irrigations withdrawals. Improving instream flows through improved water management, off-stream storage, and water acquisitions and transfers will improve rearing habitats. The Teanaway has been the focus of water conservation projects by YRBWEP, Ecology, and Kittitas County Conservation District; WDFW, the Yakama Nation, and the Kittitas Conservation Trust have been active in Swauk Creek.

Upper Yakima Action #5 **Provide passage and instream flows in lower Manastash Creek**

Key Partners:
- Kittitas County Conservation District
- Individual irrigators
- Yakima Tributary Access and Habitat Program
- Yakama Nation
- Water Trust & Conservancies

Affected MSAs:
- Manastash

Focal Area: Lower 3 miles of Manastash Creek **Implementation Likelihood:** High

Time to Implement: Expand ongoing
Time to Benefit: 3-10 years

Strategies:
Restore unimpeded fish passage
Improve flow conditions

Limiting Factors:
U4,5

Cost Derivation: $5,000,000 estimate by Kiititas County Conserrvation District.

Total Cost: $5,000,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $2,812,500

Manastash Creek has numerous small water diversions across the large alluvial fan in the lower reaches which block fish passage and can dewater the creek. Resolution of flow and passage issues in this watershed is high priority for the basin as a whole due to the quantity of suitable but unoccupied habitat in Manastash Creek and its location in the lower portion of the Upper Yakima. Work is currently underway by a local working group led by the Kittitas County Conservation District with support from the Department of Ecology and BPA.

Upper Yakima Action #6 **Provide unimpeded fish passage in Taneum Creek**

Key Partners:
- Kittitas Conservation Trust
- Yakima Tributary Access and Habitat Program
- Individual irrigators

Affected MSAs:
- Taneum

Focal Area: Lower 3 miles of Taneum Creek **Implementation Likelihood:** High

Time to Implement: > 10 years
Time to Benefit: 0-3 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
U9

Cost Derivation: Preliminary design estimates.

Total Cost: $600,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $450,000

Taneum Creek has several medium-sized diversions in the lower portions of the creek that partially block fish passage. Concrete fishways were installed in the 1980s but rarely provide full adult passage and do not allow juvenile passage. Above those diversions, flows and habitat conditions are good to excellent. Recent improved flow conditions in Taneum Creek have resulted in steelhead use of the most accessible portions of the creek. The Kittitas Conservation Trust is taking the lead on efforts to install low-maintenance fish passage structures.

Upper Yakima Action #7 **Provide fish passage into Upper Naneum Creek**

Key Partners:

City governments
Individual irrigators
Kittitas County Conservation District
Kittitas County
Yakima Tributary Access and Habitat Program
Irrigation Districts
Bureau of Reclamation

Affected MSAs:

Naneum

Focal Area: Lower and middle reaches of Naneum Creek

Implementation Likelihood: Moderate

Time to Implement: > 10 years

Time to Benefit: 10-25 years

Strategies:

Restore unimpeded fish passage

Limiting Factors:

U9

Cost Derivation: 25 structures at $200,000 each.

Total Cost: $5,000,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $3,750,000

The upper portions of Naneum Creek are presumed to have been historic spawning and rearing habitat for steelhead. There are multiple stream courses that connect the middle reaches of Naneum to the Yakima River, and coordinated planning will be required to identify the most effective route to restore. This will require the involvement of YTAHPs, the Kittitas County Conservation District, Kittitas County, the City of Ellensburg, Cascade Canal Company, Kittitas Reclamation District, Ellensburg Water Company, and private irrigators. Work will involve removing passage barriers, screening diversions, and improving instream flows.

Upper Yakima Action #8 **Provide passage at Cle Elum Dam**

Key Partners:

Bureau of Reclamation

Affected MSAs:

Cle Elum

Focal Area: Cle Elum Dam

Implementation Likelihood: Moderate

Time to Implement: 6-10 years

Time to Benefit: 10-25 years

Strategies:

Restore unimpeded fish passage

Limiting Factors:

U8

Cost Derivation: 2008 cost estimate of $96,000,000 by Bureau of Reclamation.

Total Cost: $96,000,000 **Fisheries:** 100% **Steelhead:** 20% **Steelhead Cost:** $19,200,000

Lake Cle Elum is a natural glacial lake that supported a run of sockeye salmon. When a dam was constructed to raise the lake to store irrigation water, fish passage was not provided. Providing upstream and downstream fish passage at Cle Elum Dam would open up 30 miles of high quality habitat for steelhead. The BOR Fish Passage Study gives a detailed description (BOR 2005). Actions and evaluation at Cle Elum Dam should precede actions at Keechelus and Kachess dams.

Upper Yakima Action #9 **Continue providing access to the Yakima River above Easton Dam in all years**

Key Partners:
Bureau of Reclamation

Affected MSAs:
Upper Yakima

Focal Area: Easton Dam

Implementation Likelihood: Moderate

Time to Implement: 0-3 years

Time to Benefit: 3-10 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
U9

Cost Derivation: Operational action without a specific cost.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

In projected low-flow years, BOR operating plans allow for closing the Easton fish ladder in the spring to block chinook from spawning in areas that may be subsequently dewatered. This would also block steelhead from the upper 12 miles of the Yakima River and its tributaries during spawning season. Closure of the Easton ladder has not occurred since 1996 due to the successful use of the "little flip-flop" flow regime and improvements to the Kachess outlet works, and closure of the ladder is not anticipated in the future (prior to 1996, closures occurred during the latter part of expected steelhead spawning time windows). Continuing to provide year-round access to and adequate flows in the Yakima River above Easton Dam will enable steelhead to successfully spawn and rear in this highly complex and productive reach of the Yakima River.

Upper Yakima Action #10 **Replace County Road culverts on Jack and Indian Creeks**

Key Partners:
Kittitas County Conservation District
Kittitas County
US Forest Service
Kittitas Conservation Trust

Affected MSAs:
North Teanaway

Focal Area: Lower sections of Jack and Indian Creeks

Implementation Likelihood: High

Time to Implement: 0-3 years

Time to Benefit: 3-10 years

Strategies:
Restore unimpeded fish passage

Limiting Factors:
U20

Cost Derivation: Based on preliminary project budgets.

Total Cost: $750,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $375,000

While the Teanaway system is generally accessible to steelhead, there are passage-limiting culverts where the North Fork Teanaway Road crosses Jack Creek and Indian Creek. These culverts block access to about 8.8 miles of upstream habitat. A project to replace them with fish-friendly structures is being developed by the Kittitas County Conservation District and partners.

Upper Yakima Action #11 **Restore passage, separate irrigation conveyance, and screen diversions in Ellensburg-area tributaries**

Key Partners:

- Kittitas County Conservation District
- Yakima Tributary Access and Habitat Program
- Yakama Nation
- Irrigation Districts
- Kittitas Conservation Trust
- Water Trust & Conservancies

Affected MSAs:

- Reecer
- Naneum
- Caribou

Focal Area: Dry, Reecer, and Wilson creeks and associated tributaries

Implementation Likelihood: High

Time to Implement: Ongoing

Time to Benefit: 0-3 years

Strategies:

Restore unimpeded fish passage

Limiting Factors:

U6,13

Cost Derivation: 30 structures at $200,000 each.

Total Cost: $6,000,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $2,250,000

The complicated network of tributaries in the Ellensburg area has been highly modified as part of the development of irrigation systems, roads, and other infrastructure. The Yakima Tributary Habitat and Access Program is removing passage barriers, screening irrigation diversions, and seperating irrigation water conveyence from natural streams. The lower reaches of these streams are expected to provide a dramatic increase in available rearing habitat in the Kittitas Valley that would offset the reduction in rearing habitat due to confinement of the mainstem. Monitoring should be conducted to confirm value of this habitat for rearing fish. Cost-effective implementation of this action will require careful analysis of options and prioritization of actions; current plans are to focus on resotration of selected creeks up to the Cascade Ditch crossings. Work should be coordinated with riparian restoration under Upper Yakima Action #15.

Upper Yakima Action #12 Reduce confinement of Upper Yakima River

Key Partners:

US Army Corps of Engineers
Gravel mine operators
Kittitas County
Washington State Department of Transportation
Yakama Nation
Yakima County
Bureau of Reclamation
Bureau of Reclamation

Affected MSAs:

All Upper Yakima

Focal Area: Floodplain of the Yakima River **Implementation Likelihood:** Moderate

Time to Implement: Ongoing
Time to Benefit: 10-25 years

Strategies:	Limiting Factors:
Restore floodplain connectivity/function	U10,14,24
Restore channel structure/complexity	

Cost Derivation: Estimated at 1,000 acres at $10,000/acre.

Total Cost: $10,000,000 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $3,750,000

Rearing habitat in the mainstem of the Upper Yakima River is limited by the combination of high flows and confined channels. Efforts to reduce confinement through levee setbacks and other infrastructure changes will both reduce the effect of the altered flow regime in the upper Yakima and increase effective habitat area. Proposed locations include the I-90 ponds at mile 101, the BOR's Schaake levee pullback near Ellensburg, the Selah-area (gravel pits and Taylor ditch) and sites associated the I-90 upgrades above Easton. There is the possibility of actions in other locations through setback of abandoned railroad levees and flood control levees on public lands.

Upper Yakima Action #13 **Protect & restore floodplain, riparian and in-channel habitats in Upper Yakima, Kittitas and Easton/Cle Elum Reaches**

Key Partners:

Land Conservancies
Private landowners
Yakima Tributary Access and Habitat Program
Yakima Basin Side Channels Project

Affected MSAs:

Caribou
Cle Elum
Manastash
Middle Mainstem Yakima
Naneum
North Teanaway
Reecer
Swauk
Taneum
Upper Mainstem Yakima
Upper Yakima
West Teanaway

Focal Area: Upper Yakima River and tributaries **Implementation Likelihood:** High

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**

Time to Benefit: 10-25 years Protect existing functional habitat U12,13,14,19, 21

Cost Derivation: 2,000 acres at $8,000/acre.

Total Cost: $16,000,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $8,000,000

There are several ongoing efforts to protect fisheries habitat in key Upper Yakima reaches through acquisition of land and conservation easements. These include the Yakama Nation's side channels project, the Cascade Conservation Partnership and Mountain-to-Sound Greenway Programs, and YRBWEP's acquisition efforts. Habitat restoration should be integrated with these acquisition programs. Much of this work has been guided by the Reaches Study conducted by Stanford and Snyder, which identified key alluvial floodplain reaches. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Upper Yakima Action #14 **Restore instream and floodplain habitat complexity in Swauk and Taneum creeks and Teanaway and lower Cle Elum rivers**

Key Partners:

- Kittitas Conservation Trust
- Cascade Land Conservancy
- Kittitas County
- Yakama Nation
- Washington Department of Fish & Wildlife
- Kittitas County Conservation District
- Bureau of Reclamation
- Washington State Department of Transportation
- Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:

- Cle Elum
- Taneum
- West Teanaway
- North Teanaway
- Swauk

Focal Area: Key tributraies to the Upper Yakima **Implementation Likelihood:** Moderate

Time to Implement: 4-6 years

Time to Benefit: 10-25 years

Strategies:	**Limiting Factors:**
Restore floodplain connectivity/function	U10,12,13,24
Restore channel structure/complexity	

Cost Derivation: 5 miles on Swauk, 17 on Teanaway, 10 on Taneum, 8 on Cle Elum for 40 miles total; 50% treatment = 20 mi x $100,000/mile treatment co.st

Total Cost: $2,000,000 **Fisheries:** 100% **Steelhead:** 75% **Steelhead Cost:** $1,500,000

Efforts to improve channel/floodplain connectivity and riparian habitat will improve habitat conditions in key tributares in the Upper Yakima. Activities may include placing large woody debris and engineered log jams, bank reshaping, channel reconstruction, and other instream habitat work and addressing confinment created by road beds (including US 97 on Swauk Creek). Any passage barriers in these creeks and fish-bearing portions of tributaries to these creeks should also be addressed. Specific areas in Swauk Creek and its tributaries have been inventoried as being in need of restoration; work is currently underway on the lower Cle Elum and under development for Taneum Creek.

Upper Yakima Action #15 Restore tributary riparian areas

Key Partners:

- Kittitas County Conservation District
- Kittitas Conservation Trust
- Yakama Nation
- Yakima Tributary Access and Habitat Program
- Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:

- Caribou
- Manastash
- Middle Mainstem Yakima
- Naneum
- North Teanaway
- Reecer
- Swauk
- Taneum
- Upper Mainstem Yakima
- West Teanaway

Focal Area: Tributary riparian areas **Implementation Likelihood:** High

Time to Implement: Ongoing **Strategies:** **Limiting Factors:**

Time to Benefit: 3-10 years Restore riparian condition/future LWD U13,14,19,21

Cost Derivation: 13 creeks at 3 miles/creek totals 39 miles; fencing & planting of 50% at $20,000/mile.

Total Cost: $390,000 **Fisheries:** 100% **Steelhead:** 50% **Steelhead Cost:** $195,000

Due to regulation and artificial confinement of the upper Yakima, the best available locations for rearing fish in normative flow and temperature conditions are in the lower ends of tributaries. Restoring riparian conditions will improve rearing conditions. Lower Reecer, Currier, Whiskey, Mercer, Wilson, Naneum, Coleman, Cherry, Manashtash, Taneum, Swauk, and Lmumma Creeks and the Teanaway River are all candidates; some work has been completed. This action should be integrated with the passage restoration efforts identified in other actions.

Upper Yakima Action #16 **Build conservation easements and other habitat protections into development plans**

Key Partners:

Cascade Land Conservancy
City governments
Kittitas Conservation Trust
Kittitas County

Affected MSAs:

All Upper Yakima

Focal Area: Floodplain and riparian areas throughout population area

Implementation Likelihood: Moderate

Time to Implement: 4-6 years

Time to Benefit: 10-25 years

Strategies:

Protect existing functional habitat

Limiting Factors:

U16,17

Cost Derivation: Cost for personnel to coordinate action at 2 FTE x $75,000/FTE/yr for 15 years; other costs subsumed into cost of new developments.

Total Cost: $2,250,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $562,500

Current and expected rapid population growth in Kittitas County has the potential to impact currently functioning habitat and reduce restoration options. Areas where development pressure and steelhead habitat overlap include the Teanaway River, Big and Swauk creek watersheds, the Ellensburg urban growth area and floodplain locations along the mainstem Yakima. Assuring that habitat values of riparian and floodplain habitat on private lands are protected and that development does not impair upland watershed processes are high priorities. This will require community-led efforts to 1) utilize the planning processes required by the Growth Management Act, 2) work with developers to promote incorporation of greenbelts and open space that protect fish habitat and reduce flood damages, and 3) develop innovative approaches that integrate habitat protections with ongoing efforts to protect open space, recreational values, livable communities, and working landscapes while protecting private property rights. The recent Suncadia development provides one example of extensive environmental mitigation being incorporated into a successful development proposal.

Upper Yakima Action #17 **Protect Teanaway watershed from negative impacts of development**

Key Partners:
- Land Conservancies
- Washington Department of Fish & Wildlife
- Kittitas Conservation Trust
- US Forest Service
- Bureau of Reclamation

Affected MSAs:
- North Teanaway
- West Teanaway

Focal Area: Teanaway River watershed **Implementation Likelihood:** High

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**

Time to Benefit: 10-25 years Protect existing functional habitat U16,17

Cost Derivation: $1,004,740 currently allocated to KCT easement proposals; also easements on 365 acres (~600' over 50% of 10 miles at $10,000/acre).

Total Cost: $4,654,740 **Fisheries:** 75% **Steelhead:** 50% **Steelhead Cost:** $1,745,528

The Teanaway watershed is currently subject to intense recreational/residential/retirement development pressure as large forestland holdings are sold off. Assuring that habitat values of riparian and floodplain habitat on private lands are protected and that development does not impair upland watershed processes are high priorities; land acquisitions, conservation easements, and cooperative agreements with developers will be key tools in ensuring these protections. This action will need to be integrated with ongoing efforts to protect open space, recreational values, and working landscapes. Cost estimates for acquisition of land and easements are generic estimates based on possible amounts; any actual acquisitions will be based on voluntary agreements negotiated with landowners.

Upper Yakima Action #18 **Relocate forest roads and campsites and revegetate clearcuts in the Teanaway River watershed**

Key Partners:
- Washington Department of Natural Resources
- Private landowners
- US Forest Service
- Regional Fisheries Enhancement Group or other volunteer groups

Affected MSAs:
- North Teanaway
- West Teanaway

Focal Area: Forestlands in the Teanaway watershed **Implementation Likelihood:** High

Time to Implement: Expand ongoing **Strategies:** **Limiting Factors:**

Time to Benefit: 3-10 years Improve upland watershed conditions U21,22,23

Cost Derivation: 30 miles of road work at $5,000/mile; 500 acres of plantings at $300/acre.

Total Cost: $300,000 **Fisheries:** 50% **Steelhead:** 50% **Steelhead Cost:** $75,000

Because of its south-facing aspect and steep, confined nature of the tributaries, the Teanaway is especially prone to increases in peak flow resulting from changes in watershed condition. Actions that improve forest practices, such as addressing the impacts of roads located next to salmon-bearing streams and revegetating clear cuts south-facing slopes, will help protect and improve watershed function. Efforts to relocate and reduce soil compaction at dispersed campsites will also improve watershed function. Due to the critical nature of all salmonid populations that inhabit the Teanaway, this watershed has the highest priority for identifying and reducing impacts from forest practices in the subbasin.

Upper Yakima Action #19 **Coordinate water quality improvements in Reecer, Wilson, Naneum, Cherry, Coleman, and Dry creeks**

Key Partners:
- Individual irrigators
- Kittitas County Conservation District
- USDA Natural Resource Conservation Service
- Department of Ecology
- City governments
- Irrigation Districts
- Washington Department of Natural Resources

Affected MSAs:
- Caribou
- Naneum
- Reecer

Focal Area: Ellensburg-area watersheds

Implementation Likelihood: Moderate

Time to Implement: Expand ongoing

Time to Benefit: 3-10 years

Strategies:
- Improve water quality

Limiting Factors:
- U17

Cost Derivation: Costs of Clean Water Act programs not attributed to steelhead recovery.

Total Cost: **Fisheries:** **Steelhead:** **Steelhead Cost:**

Water quality in Ellensburg-area tributaries is degraded by agricultural activities, urban stormwater, and forestry activities in the upper watersheds. Agricultural practices are improving, but more work is needed on stormwater and reduction of peak flows from forestry activities. A sediment TMDL is being developed for the Upper Yakima; implementation is currently limited by funding.

Upper Yakima Action #20 **Restore tributary headwater meadows**

Key Partners:
- US Forest Service

Affected MSAs:

Focal Area: Headwaters of key Upper Yakima tributaries

Implementation Likelihood: High

Time to Implement: 4-6 years

Time to Benefit: 3-10 years

Strategies:
- Improve flow conditions
- Improve water quality

Limiting Factors:
- U26

Cost Derivation: Cost for restoration crew time & equiment at 30,000/yr for 15 yrs.

Total Cost: $450,000 **Fisheries:** 75% **Steelhead:** 75% **Steelhead Cost:** $253,125

Protecting and restoring the function of wet meadows in the upper watersheds of Swauk, Taneum, and Manashtash creeks and Cle Elum River and its tributaries (e.g. Thorp and French Cabin creeks) will help maintain and improve the quantity and quality of instream flows in downstream steelhead habitat. For the Cle Elum watershed, this only becomes relevant pending completion of Upper Yakima Action #8: Provide passage at Cle Elum Dam.

Upper Yakima Action #21 **Provide adequate late fall/winter flows below storage dams**

Key Partners:

Bureau of Reclamation

Affected MSAs:

Cle Elum
Upper Yakima

Focal Area: Upper Yakima and Cle Elum rivers **Implementation Likelihood:** Moderate

Time to Implement: 0-3 years
Time to Benefit: 0-3 years

Strategies:

Improve flow conditions

Limiting Factors:

U2

Cost Derivation: Operational change; no specific cost identified.

Total Cost: **Fisheries:** 100% **Steelhead:** 25% **Steelhead Cost:**

Late fall/winter flows below Kachees, Keechelus and Cle Elum reservoirs are maintained at relatively low levels by releases from the storage dams as natural reservoir inflows are used to refill storage capacity. Releases may also vary substantially based on flood control operations and efforts to assure adequate storage in dry years. The primary fisheries emphasis in this area is on maintaining appropriate spawning and incubation flows for spring Chinook. Consideration should also be given to ensuring productive spawning and rearing conditions for juvenile steelhead.

6 Plan Implementation

6.1 Approach to Implementation	**6.4 Adaptive Management**
6.2 Funding Strategies	**6.5 Removing Roadblocks to Implementation**
6.3 Implementation Scheduling	**6.6 Links to Larger Recovery Efforts**

This plan is a beginning, not an end. It identifies proposed recovery actions, lays out a framework for assessing progress towards recovery goals, and identifies issues that will need to be assessed during recovery efforts. Implementing the plan and achieving recovery goals will require sustained long-term efforts by a wide range of stakeholders. Coordinating these efforts and ensuring that limited funding is used effectively will require ongoing collaboration within the basin and between in-basin stakeholders and state, tribal, and federal entities. This chapter gives an overview of what will be required to achieve this coordination.

6.1 Approach to Implementation

6.1.1 Voluntary and Non-Regulatory Nature of Plan

As noted in section 1.2.3, both the NOAA Fisheries' Recovery Plan for the Middle Columbia River Steelhead DPS and the Yakima Subbasin Salmon Recovery Plan are not regulatory documents. Both promote cooperative and voluntary approaches to undertaking recovery actions. For this voluntary approach to work, recovery plan implementation will need to be supported by broad outreach, targeted technical and logistic support to landowners and project proponents, and funding and incentive programs that support recovery actions.

This plan does not make specific recommendations to change existing regulatory programs, but does recognize that how regulatory programs are implemented will affect the progress of steelhead recovery. Elected officials, agency staff, stakeholder groups, and voters should consider the recovery needs of steelhead as these programs are established, revised, and implemented.

Effectively designed and well-implemented regulatory programs that strike an appropriate balance between habitat protection and other legitimate land use goals will be a critical component of salmon recovery. Specific regulatory programs that intersect with steelhead recovery include local land use management such as the Growth Management, Shorelines, and Critical Areas Ordinance programs of local governments; the establishment and enforcement of fisheries regulations by WDFW; the implementation of the ESA by NOAA Fisheries (including issuance of Section 7 Biological Opinions and Section 10 take permits); development and implementation of Total Maximum Daily Loads (TMDLs) in accordance with the Clean Water Act; and the issuance of instream work permits by WDFW, WDOE, the Yakama Nation and the U.S. Army Corps of Engineers. Our hope is that the information and proposed actions in this plan can inform ongoing public dialogues about implementation of these regulatory programs.

6.1.2 Coordination of Existing Recovery Programs

Salmon recovery is not a new pursuit in the Yakima Basin. Fish screening efforts began in the early 20th century, and intensive recovery efforts have been ongoing since the 1980s. The steelhead recovery actions proposed in this plan are a natural extension of this work and should build upon existing programs, relationships, and funding sources whenever possible. Developing collaborative partnerships among existing organizations should take precedence over the creation of new organizations and programs unless there is a clear need for a new structure.

The Yakama Nation and the WDFW have played a central role in salmon recovery work in the Yakima Basin. Much of the funding has come from the BPA with oversight from the Northwest Power and Conservation Council, which was established by the Northwest Power Act of 1980. BPA is currently working with basin stakeholders to target its funding in a manner that meets power planning act requirements and contributes to mitigating the impacts of the Federal Columbia River Power System on ESA-listed species. This is occurring as part of the negotiation of an ESA-mandated Biological Opinion for the Federal Columbia River Power System; a draft Biological Opinion was released in October 2007.

Another significant source of funding for recovery actions is the federal Pacific Coast Salmon Recovery Fund (PCSRF). Washington has used its allocation of PCSRF funding along with state funding to support salmon recovery efforts overseen by the Washington Salmon Recovery Funding Board (SRFB). To date, over $8.7 million has been committed to salmon recovery projects in the Yakima Basin via Salmon Recovery Funding Board (SRFB) programs; this funding has leveraged another $5.5 million in locally secured match from diverse sources.

The BOR has also been a key supporter of salmon recovery efforts in the Basin (see Section 6.1.4 for more detail). Federal, state, tribal, and private land managers have incorporated salmon recovery needs into their land management activities and plans (see Section 6.1.5). Local governments, irrigation districts, the South-Central Washington RC & D, and conservation districts have all become active proponents of salmon recovery projects and have built the organizational capacity needed to plan, fund, and implement these projects.

Most of the recovery actions outlined in this plan can be implemented through these programs. This will require ongoing efforts to coordinate diverse programs and identify joint priorities to ensure that recovery efforts build on existing capacities and are implemented efficiently.

6.1.3 Coordination with Bureau of Reclamation Yakima Project

For the last 20 years, BOR has been improving fish passage and installing protective facilities in the Yakima Basin. They maintain a project list and inventory of pending and proposed projects that conserve fish resources and are actively balancing fish requirements and water production needs in Yakima Project operations.

Congress established the Yakima River Basin Water Enhancement Project (YRBWEP) in 1994. YRBWEP has funded a wide range of salmon recovery actions, including major irrigation system improvements, purchase of water rights for transfer to instream flow, cooperative projects with smaller irrigators, and purchase and management of floodplain habitat in key river reaches. BOR also works closely with the System Operations Advisory Committee (SOAC), which consists of representatives of WDFW, the Yakama Nation, the USFWS, and the Yakima Basin Joint Board and was created by the Yakima Basin watermaster in 1981. SOAC provides recommendations to BOR on how fish needs are incorporated into Yakima Project operations.

BOR is working closely with WDFW and the Yakama Nation to assess the possibility of re-establishing fish passage at the five storage dams (see section 4.3.3) through the Storage Dam Passage Feasibility Study scheduled for completion in 2008. The Yakima Basin Storage Study is a major effort by BOR to identify and assess options for increasing water storage capacity in the Yakima Basin to better meet the long-term water supply needs of agriculture, municipal users, and anadromous fish. The draft EIS for the storage study is also due in 2008.[39] Models and other planning documents that BOR is developing as part of the storage study have great potential for informing broader discussions of recovery needs.

In a meeting on February 28, 2005 and in a subsequent letter, BOR staff identified existing projects that could contribute to a salmon recovery plan. As with all federal agencies interviewed, they identified limited budgets and resources as a concern in assisting with salmon recovery planning efforts.

BOR submitted extensive comments on the October 2005 version of the Yakima Subbasin Salmon Recovery Plan and drafts of this steelhead extract. The Yakima Basin Fish & Wildlife Recovery Board will work with BOR to continue these discussions. Several key actions identified in this plan involve BOR and will only move forward to the degree that BOR supports them. The Board hopes that this plan will be a useful document for BOR as it continues its efforts to protect and enhance Yakima Basin steelhead.

6.1.4 Coordination with Land Management Agencies

The USFS, the Bureau of Land Management, the USFWS, and the Washington Departments of Natural Resources and Fish and Wildlife all manage lands in the Yakima Basin. Their management activities are governed by a range of laws, plans, and agreements, including some that specifically address management needs of listed fish species (e.g., Biological Opinions, Habitat Conservation Plans, and the Forests and Fish Act). In addition to general land management decisions, these agencies have many opportunities to undertake specific recovery projects, but rates of implementation are constrained by staffing and budget limitations. These agencies will be key participants in

[39] The BOR's study is coupled with work by the Washington State Department of Ecology to assess non-storage options for improving basin water supplies.

ongoing efforts to prioritize, coordinate, fund, and implement recovery actions identified in this plan.

6.1.5 Coordination with Other Planning Efforts

Section 1.4.1 discussed the relationship between this plan and the Yakima Subbasin Plan and the Yakima Basin Watershed Plan. Other planning efforts that will inform and guide actions called for in this plan include:

- Flood Hazard Management Plans developed by local counties
- Statewide Steelhead Management Plan currently under development by the WDFW
- Steelhead Master Plan being developed by the Yakima/Klickitat Fisheries Project, Comprehensive Irrigation District Management Plans developed by local irrigation districts
- Land management plans developed by the USFS, the BLM, and the Washington Department of Natural Resources
- Capital facilities improvement plans developed by local, state, tribal, and federal governments to guide work on highway systems, water systems, and other critical infrastructure that influences steelhead habitat

It is our intent that this recovery plan and the ongoing collaborative network on which it is built can help make it easier for these diverse groups of planners to understand and incorporate steelhead recovery needs into these plans. The Yakima Basin Fish & Wildlife Recovery Board is committed to working with all of these partners.

6.1.6 Coordination with Local Land Use Planning

While this plan does not make any specific proposals regarding land use planning or associated regulations, local jurisdictions are encouraged to review local subdivision ordinances to see if they encourage creative approaches that balance habitat protection with site planning (possible examples include density bonuses, transfers of development rights, binding site plans, and tax incentives). Local jurisdictions are also encouraged to use the information in this recovery plan as they review their Critical Areas and Shorelines and Flood Hazard Management ordinances to see if they address habitat protection in a consistent and logical manner that avoids redundancy, uses the best available science, and works with adjacent jurisdictions to assure that ordinances do not conflict across the landscape. Cities and counties are also encouraged to seek funding to monitor adherence to development permit conditions and how effectively they met their intended goals.

6.1.7 Role of Yakima Basin Fish & Wildlife Recovery Board

Early in the recovery planning process, planners realized that existing structures, while adequate for supporting the initial development of subbasin and recovery plans (via the

Yakima Subbasin Fish & Wildlife Planning Board) and allocating SRFB funding through the Lead Entity structure (via the Yakima River Basin Salmon Recovery Board), were not capable of coordinating long-term recovery efforts. In response, the two organizations merged to form the Yakima Basin Fish & Wildlife Recovery Board (YBFWRB) in April of 2006. Since then, the YBFWRB has hired a director and staff, secured funding from WDFW and the SRFB, established offices, acted as the Lead Entity for SRFB programs in the Yakima Basin, and coordinated the recovery plan revision process and development of this steelhead extract. The YBFWRB anticipates a key role coordinating and supporting recovery actions and associated research, monitoring, and evaluation efforts (See Chapter 7). The YBFWRB is also planning a strong outreach program that builds community knowledge of and support for salmon recovery actions (See Chapter 8).

6.2 Funding

6.2.1 Total Time and Cost of Recovery

Initial cost estimates for implementing all of the actions identified in this plan over 15 years total $1,168.3 million, with $269.3 million of that cost attributed to steelhead recovery. The remaining portion of the total cost is attributed to other sources based on anticipated benefits to agricultural producers (e.g. irrigation system improvements), flood control, open space, other fish and wildlife species, etc, according to the percentages identified in the action descriptions. Funding steelhead recovery actions will require working with other interests and entities to ensure that full funding can be secured for actions whose benefits to society extend beyond steelhead recovery.

This is a simple and very preliminary estimate of actual implementation costs for actions. It is not a cost-benefit analysis of the proposed actions and does not include indirect costs such as opportunity and compliance costs associated with recovery efforts. It should not be taken as the total cost of recovery, as achieving delisting goals may require only implementing some of the actions included in this plan, while long-term recovery may require additional actions not included in the plan.

This estimate does not include specific costs for steelhead-related monitoring, which will be an essential component of recovery efforts. An initial placeholder of $300,000/yr for 15 years for steelhead-specific monitoring equals $4.5 million; cost estimates will be refined as a more detailed monitoring plan is developed (see discussion in Chapter 7).

6.2.2 Funding Sources

Significant funding is already available for salmon recovery in the Yakima Basin via the BPA Fish and Wildlife Program, SRFB programs, the Department of Ecology Columbia River Initiative, USDA programs like EQIP and CREP, and others. The Board will work with existing programs and partners to help ensure that funding is targeted to ensure real progress towards recovery. A broadly supported implementation schedule for recovery actions will be a key element in guiding how funding is applied (see Section 6.3).

Where existing funding sources are insufficient or cannot be applied to key recovery actions, the YBFWRB will work with partners to help secure new funding sources for recovery actions. Sources may include local, state, and federal appropriations, special improvement districts, grants from foundations, support from private businesses, and private donations. Many of the proposed actions have multiple benefits that extend far beyond salmon recovery. Funding for these may involve complex packages of funding from multiple sources, each of which focuses on specific sets of benefits, any one of which may or may not include salmon recovery.

Different funding sources have different goals, mandates, and application and contracting procedures. Increasing knowledge of different funding sources and their requirements, and streamlining application and contracting procedures would significantly reduce the transaction costs associated with recovery projects. The Board anticipates working with grantors and implementing organizations to increase efficiencies.

6.3 Implementation Scheduling

The YBFWRB has committed to maintaining an implementation schedule that identifies priority recovery actions and sets a schedule for implementing them. The Board will develop this schedule and update it at least annually in coordination with potential project sponsors, partners, and affected stakeholders. The implementation schedule does not create any formal obligations or commitments; it is will serve as a guide to recovery priorities and an informal record of commitments made in other forums.

The implementation schedule should serve as a menu from which project proponents can chose projects to implement. These choices should be guided by the following considerations:

- The degree to which projects address a priority limiting factor for steelhead
- The technical feasibility of implementing a project
- The level of certainty regarding project outcomes and the long-term response to them by steelhead populations
- The strength of the commitment of the parties involved in a project to implement and maintain it
- The cost-effectiveness of a proposed action
- The presence of a “champion” organization or individual with the interest and ability needed to develop and implement the action
- The presence or absence of general community support for a project
- The availability of funding that can be used for that specific project
- The presence of temporary windows of opportunity for completion of a project

Evaluating the effectiveness of implemented recovery actions and identifying future priorities will require a rigorous and quantitative approach to adaptive management as

priority actions are being implemented. The implementation schedule will have to be adjusted over time based on monitoring results, as noted below under Adaptive Management in Section 6.4. Detailed recommendations on implementing a strong adaptive management process will be included in the RME supplement to the Yakima Steelhead Recovery Plan currently being developed by the YBFWRB. We encourage interested parties to participate in the development of the supplement and the ongoing maintenance of the implementation schedule.

The implementation schedule should become a widely used resource that informs project selection. In some contexts (e.g., SRFB project selection) it may become a driving force. However, given the diversity of project partners, funding sources, and the mandates and goals behind recovery actions, actions that are designated recovery priorities will continue to be funded by a wide range of programs that may be informed or guided by the implementation schedule, but are not specifically directed by it.

6.4 Adaptive Management

A key to effective implementation of this plan will be the use of a rigorous adaptive management framework that identifies and addresses key uncertainties through monitoring and research. This will include:

6.4.1 Tracking Implementation

The Board will work together with partners implementing recovery actions to track project completion, document their outcomes, and evaluate whether they are carried out as planned. Project summaries that describe what project sponsors accomplished, document project outcomes and lessons learned, and include maps and project photos will be assembled and maintained in a publicly accessible format. The YBFWRB will use this information to develop regular reports on the status of plan implementation.

6.4.2 Monitoring Habitat and Population Trends

To assess the effectiveness of recovery efforts and sustain the support of the public and key decision makers, we must be able to track progress towards recovery goals. This requires reliable empirical estimates of population status that can be compared to the recovery criteria identified in this plan. The Yakima Basin currently has an ability to monitor anadromous fish runs that has few equals in the region, thanks largely to the fish research infrastructure established by the Yakima/Klickitat Fisheries Project. However, effectively tracking the full range of VSP parameters (abundance, productivity, spatial structure, and diversity) for each individual population will mean adjusting and supplementing our monitoring programs. Chapter 7 describes current efforts to identify and implement the required steelhead population monitoring.

6.4.3 Designing Recovery Actions to Test Key Assumptions

Adaptive management is a powerful concept that is often misrepresented as simply regularly monitoring and reassessing progress. Effective adaptive management requires the application of the principles of experimental design to management actions so that

they test basic hypotheses that improve our understanding of key uncertainties and help us better understand ecosystem responses to our actions. Chapter 7 describes the role of adaptive management in plan implementation and the key uncertainties identified during this planning process.

6.4.4 Revising the Recovery Plan

This plan should be a living document that is revised to reflect improved understanding of key uncertainties, account for progress towards recovery, and refine assessments of future recovery needs. Annual reports by the YBFWRB will describe progress in plan implementation. Plan revisions will be considered at least every five years in conjunction with the five-year status reviews to be conducted by NOAA Fisheries.

6.5 Removing Roadblocks to Implementation

Once actions have been identified and chosen as priorities, the actual work of implementation begins. This is often a complex process that consumes significant amounts of time and funding. Efforts that increase the efficiency of project implementation and remove known roadblocks will play an important role in speeding up the rate of recovery. Possible areas to focus are described below.

6.5.1 Permit Streamlining

It is ironic that those implementing fish habitat improvement projects often see state, federal, and local regulations as impediments, even though these regulations are designed to protect habitat and listed species. Streamlining permitting processes for recovery actions would greatly reduce the transaction costs associated with implementing recovery actions and increase the rate at which recovery actions are implemented. Recent efforts by the Governor's Salmon Recovery Office to work with NOAA Fisheries, the Corps of Engineers, and the USFWS to incorporate SRFB-approved actions identified in NOAA Fisheries-accepted recovery plans into programmatic permits are an excellent first step.

6.5.2 Providing ESA Assurances

In many cases, potentially valuable projects are not implemented out of participants' fears that they may create future liabilities under the ESA (e.g., refusing to improve fish passage on a creek based on fears that the presence of listed fish in previously blocked areas would create a new regulatory burden). This could be addressed through mechanisms and agreements that support good-faith recovery efforts based on the best scientific information available and limit or absolve any future liabilities that the projects might create. Legally binding mechanisms to discharge responsibility for impacts to steelhead populations based upon the performance of recovery actions could significantly increase voluntary participation in recovery planning. There are some existing programs to accomplish this under the ESA (Habitat Conservation Plans, Safe-harbor agreements, etc.), while other programs may need to be developed to meet specific needs.

6.5.3 Building Technical Capacity

Complex recovery actions require a range of expertise unavailable in local communities and small organizations. Resources can be shared to build the capacity to get these actions on the ground. Examples of new and existing technical capacity that could be shared among multiple recovery partners include engineering, geographic information systems, land transaction (especially regarding structuring, valuation, monitoring, and enforcement of conservation easements), and fund raising for large projects.

6.5.4 Supporting Network of Recovery Practitioners

Most groups implementing recovery actions are either small organizations or small units within large organizations with other areas of focus. Successful recovery actions will be built on effective communication between diverse groups and individuals. It will require networks that help people sustain a global understanding of recovery efforts while maintaining focus on their individual components. Networks of recovery practitioners and stakeholders (be they formal or informal) will be an important way of building capacity, sharing lessons, and sustaining mutual support and momentum.

6.6 Maintaining Links to Larger Recovery Efforts

While this plan focuses on steelhead recovery needs within the Yakima Basin, achieving steelhead recovery goals will also require coordination with actions taken outside of the basin. This will require recovery planners and other local stakeholders to engage in several state and regional processes, as discussed below:

6.6.1 Washington State Salmon Recovery Strategy

The State of Washington's Governor's Salmon Recovery Office (GSRO) recognizes the Yakima Basin Fish & Wildlife Recovery Board as one of six regional recovery organizations in the state. The Yakima Subbasin Salmon Recovery Plan that this extract is based on has been accepted as a regional salmon recovery plan in accordance with the Salmon Recovery Act (RCW 77-85). The GSRO and the SRFB are committed to using regional salmon recovery organizations as a key element in the statewide salmon recovery process, and the Yakima Basin Fish & Wildlife Recovery Board is committed to working with the state in this capacity. The Board is also under contract with WDFW to serve as the Lead Entity for the Yakima Basin. Based on these two commitments, the Board coordinates applications for SRFB funding of projects in the Yakima Basin and intensive local reviews of proposals to the SRFB. The Board is committed to making this plan an integral part of the Yakima Basin SRFB proposal review process. The Board will also work with GSRO on regional sections of the biennial State of the Salmon report produced by GSRO as required by state law. The legislature has designated regional recovery organizations as members of the Washington Forum on Monitoring Salmon Recovery and Watershed Health, which seeks to coordinate salmon recovery monitoring efforts throughout the state.

6.6.2 Middle Columbia DPS-wide Coordination

The Yakima Basin's steelhead make up only one of the four Major Population Groups that together comprise the Middle Columbia River Steelhead DPS. The geographic area of the Middle Columbia River Steelhead DPS encompasses a large part of north-central Oregon and south-central Washington. Under the ESA, delisting decisions are made at the level of the DPS as a whole. This means that steelhead in the Yakima Basin may meet recovery goals, but not be delisted due to conditions elsewhere in the DPS. Communities throughout the DPS must undertake targeted recovery actions to successfully meet recovery goals and delist the DPS. This process will be facilitated by ongoing communication and coordination among these communities. An initial step is being made as part of the development of the Mid-Columbia Steelhead Recovery Plan by NOAA Fisheries, in which local planning groups from Oregon and Washington are meeting regularly to discuss how plans developed for individual MPGs will be 'rolled up' into a DPS-wide plan to be issued by NOAA. The Yakima Basin Fish & Wildlife Recovery Board anticipates that the need to share information and resources and coordinate key recovery actions across the entire DPS will continue during recovery plan implementation. The Board is committed to continuing to engage in discussions at the DPS level.

6.6.3 Integration with Columbia River, Estuary and Ocean Recovery Efforts

Conditions and management actions in the Columbia River, its estuary, and the ocean inevitably affect the fate of steelhead in the Yakima Basin. The rate of progress towards recovery will be determined, in part, by decisions made in these areas. Although this plan focuses on actions within the Yakima Basin, it recognizes that in-basin stakeholders will also need to engage in decision making outside of the basin to ensure that in-basin actions are coordinated with out-of-basin actions. Some stakeholders in the Basin (e.g., WDFW, the Yakama Nation, and the BOR) are directly involved in key out-of-basin management decisions; others have the opportunity to participate via established public participation processes and associations with other decision makers. The Yakima Basin Fish & Wildlife Recovery Board anticipates participating in efforts to coordinate overall Middle Columbia River Steelhead DPS recovery efforts. The Board will also foster discussions about the best way for in-basin stakeholders to ensure that progress outside of the basin continues to complement the concerted efforts underway within the basin.

7 Research, Monitoring and Evaluation

7.1 Steelhead Population Trends	**7.5 Critical Ecological Dynamics**
7.2 Key Factors Affecting Survival	**7.6 Impact of Long-term Trends**
7.3 Habitat Trends and Threats Criteria	**7.7 Coordinating Research & Monitoring**
7.4 Recovery Action Effectiveness	**7.8 Out-of-Basin RME Needs**

Steelhead recovery occurs in a complex setting. There are numerous uncertainties about the status of steelhead populations, trends in habitat conditions, and the response of steelhead to recovery actions. Ongoing research, monitoring, and evaluation will be an essential element of recovery efforts. Research and monitoring must be targeted to address critical uncertainties, many of which were identified earlier in this plan and are described more fully in this chapter. The Yakima Basin Fish & Wildlife Recovery Board is tasked with developing a research, monitoring, and evaluation (RME) plan for steelhead recovery efforts. It will be working closely with in-basin partners, WDFW, the Yakama Nation, and NOAA Fisheries to identify key actions and coordinate their implementation. This chapter gives an overview of topics that will be addressed in more detail in the proposed RME plan.

Chapter 6 addressed monitoring of implementation of recovery actions. Monitoring long-term trends for the basin's four steelhead populations will be essential for assessing progress towards the recovery criteria identified in Chapter 4. Understanding long-term trends in habitat conditions and other factors affecting survival will allow objective assessments of progress towards addressing the threats criteria NOAA Fisheries is developing as part of the Middle Columbia River Steelhead Recovery Plan. Both types of information will be required to assess prospects for de-listing Middle Columbia River Steelhead DPS.

Monitoring and research also improve our understanding of how recovery actions affect steelhead populations. Evaluating how recovery actions affect habitat conditions and how steelhead respond to those changed conditions will guide the choice and design of subsequent recovery actions. Work focusing on the ecological and climatic dynamics of steelhead habitat—both in and outside of the Yakima Basin—will also be critical.

To implement this recovery plan, we will need an adaptive management framework that addresses the key uncertainties identified here through management experiments. This will require:

- Careful coordination between those implementing recovery actions on the ground and the research community
- Identification of key uncertainties and hypotheses about their links to steelhead recovery
- Development of system models that guide discussion about factors affecting steelhead recovery

- Incorporation of experimental design concepts into management actions

This adaptive management framework will be developed in more detail in the upcoming Research, Monitoring and Evaluation Plan.

7.1 Understanding Steelhead Population Trends

The ESA calls for status reviews for listed species every five years. Ongoing monitoring of steelhead populations will be required to allow objective comparisons between current status and trends of key VSP parameters and the recovery criteria identified in Chapter 4. This work should be closely coordinated among NOAA Fisheries, the Interior Columbia Technical Recovery Team, WDFW, the Yakama Nation, and the Yakima Basin Fish & Wildlife Recovery Board.

Research and monitoring efforts should also evaluate the appropriateness of the recovery criteria identified in Chapter 4 so that the criteria can be adjusted as needed. Two areas where research and monitoring efforts will directly inform the revision of recovery goals are:

- Evaluating the current and potential role of mainstem spawning in recovery scenarios and using that information to determine how to produce the “mainstem spawners” block identified under the Satus population in Chapter 4
- Understanding the dynamics underlying the balance between resident and anadromous life histories in the Upper Yakima and Naches populations to determine realistic long-term population goals for both steelhead and rainbow trout

This section gives a brief overview of current and proposed monitoring and research that focuses on understanding steelhead population VSP parameters.

7.1.1 Abundance and Productivity

The existing ability to track MPG-level abundance trends via ladder counts at Prosser is excellent and needs to be maintained. Our current ability to track abundance at the population level is variable, with the strongest estimates from Roza Dam counts for the Upper Yakima and the weakest from the Naches basin, which has no dam counts and redd counting conditions that make it difficult to estimate spawner abundance. Two proposals are currently being developed to allow improved tracking of abundance by population. The first relies on using genetic sampling of the adult and/or juvenile migrations at Prosser and using genetic signatures to attribute fish to specific population areas. Feasibility studies are currently under way by WDFW’s genetics lab in Olympia. The second calls for radio tracking to apportion steelhead passing Prosser to their eventual destination and would repeat and update the 15-year old study referenced in this plan (Hockersmith et al. 1995). The two efforts would be complementary since the radio tracking would help develop pre-spawning mortality rate estimates and help assess effectiveness of genetic population attribution. Both proposals will be developed in more detail in the upcoming RME plan.

7.1.2 Spatial Structure

Existing Monitoring of Spatial Structure

Our current knowledge of spatial structure is based on redd counts and radio-tracking data. The BPA-funded Yakama Nation Watersheds Project conducts extensive monitoring in the Satus, Toppenish, and Ahtanum creek watersheds. The redd surveys conducted by this program are the primary basis for understanding steelhead spatial structure in these watersheds and should be continued.

Redd surveys have been conducted in the Naches basin since 2004. The USFS Naches Ranger District and WDFW have led these efforts with support from other agencies. This has significantly expanded our knowledge of spawner distribution in the area, although high and turbid flows during the spawning season limit the utility of redd counts for estimating spawner abundance.

Our most current knowledge of spatial structure in the Upper Yakima population area comes from radio tracking conducted by BOR and YKFP in 2002 through 2005. This work provided a detailed picture of spawner distribution during this time period; it did not address the portion of the Upper Yakima population that spawns below Roza Dam. This work ended in 2005.

Improve Tracking of Upper Yakima and Naches Distributions

Effectively tracking long-term trends in spawner distributions in the Upper Yakima and Naches populations will require a combination of methods, including targeted redd counts in areas and years when conditions are favorable, periodic radio tracking from Prosser and/or Roza, and the use of new tagging and detection technologies—such as inserting PIT or acoustic tags in adults at Prosser and using detector arrays to track movements into tributaries, and using sonar-based detection systems, and installing automated counting facilities at key passage structures. Specific proposals and budgets will be developed as part of the RME plan.

Role of Mainstem Spawning

Our understanding of past, current, and potential future steelhead spawning in mainstem reaches is limited. The mainstem Yakima and Naches rivers and their complex of side-channels are generally presumed to have supported significant numbers of steelhead spawners prior to the population declines of the last 150 years. Changes in hydrology and significant reductions in the extent and function of floodplains are presumed to have significantly reduced the extent and success of mainstem spawning, especially downstream of Union Gap, but hard data are lacking. Redd surveys are generally not feasible in mainstem reaches because flows are often high during the spawning season. Two major radio-tracking efforts in the basin found relatively high rates of mainstem spawning (Hockersmith et al. 1995; Karp et al. 2003; Karp et al. 2005). Additional radio tracking is likely to be the most effective way to increase our understanding of the current extent of mainstem spawning and the microhabitats used by mainstem spawners. Further work is needed to determine the key factors that affect reproductive success of mainstem spawners. This will be a critical part of evaluating where mainstem spawning should be

encouraged or discouraged in the course of recovery. As noted in Chapter 4, current uncertainties about the feasibility and success of mainstem spawning below Union Gap led recovery planners to identify a block of spawners from the Satus population that could either be produced from the mainstem Yakima or mitigated for by increased production elsewhere in the basin. Research that informs which of these alternatives to choose will help guide recovery efforts.

Rates of Reestablishment of Steelhead in Previously Blocked Areas

Significant efforts are being made to restore passage to parts of the basin that have been blocked by dams and other barriers. Passage barriers have been recently removed from Cowiche and Big creeks. Passage barrier removal is underway in Manastash and Taneum creeks and is proposed for Naneum Creek and the Cle Elum and Bumping rivers. Understanding the recolonization process is critical to 1) ensuring that significant investments in passage provide anticipated benefits, and 2) evaluating the possible need for short-term supplementation to re-establish populations in previously blocked areas.

7.1.3 Diversity

Currently, our understanding of the extent and role of phenotypic and genetic diversity in Yakima Basin steelhead populations is limited. Our understanding of population specific phenological and life history traits will be greatly improved by the anticipated ability to identify upstream migrants by population at Prosser.

Phenotypic Diversity

Fish measured at adult traps associated with fish ladders at Prosser and Roza dams are the best source of data on spawner lengths, weights, condition, and other phenotypic traits. Smolt lengths, weights, and condition can all be assessed at smolt traps (Prosser and Roza dams and tributary screw traps). Improving existing smolt and parr sampling and establishing new trapping locations should be considered. Data on phenological traits should be reviewed for correlation with run timing, genetic differences, and between and within population spatial distribution.

Genetic Diversity

The genetic sampling proposed to improve tracking abundance by population will also provide ample data for analyses of genetic diversity within and among the four populations. Radio-tracking data of genetically profiled individuals and/or spawning ground genetic samples can be used to assess inter-population stray rates and identify genotypic variations in habitat use.

Hatchery Genetic Inputs

Hatchery steelhead are not currently released in the Yakima Basin, and strays from others areas have comprised less than 5% of the total run on average, but the risk of long-term genetic impacts from interbreeding with hatchery stocks remains. We must continue current efforts to:

- Identify and track the hatchery component of steelhead runs, both at Prosser, and where possible, on the spawning grounds
- Assess genetic introgression from hatchery steelhead and rainbow trout in the Upper Yakima and Naches populations

Understanding and Monitoring Life History Diversity

As described in Chapter 2, our current understanding of steelhead life history diversity in the Yakima Basin is limited. Monitoring and research that improves our understanding of life history diversity within and among populations will allow recovery planners to build more explicit recovery criteria for the diversity component of the VSP framework.

Genetic sampling and PIT tagging can be used to build population specific estimates of run timing. Combining scale samples with this information can be used to determine age structures by population.

Understanding juvenile migration patterns between emergence and smoltification will be more challenging but essential. Key questions include:

- Comparing the frequency and relative survival benefits of different juvenile migration patterns (e.g., smoltification upstream vs. downstream movement of pre-smolts in late fall and winter)
- Distinguishing the role of mainstem and floodplain rearing habitat and the impacts on life history patterns from the loss of these rearing habitats in many parts of the basin (e.g., simplified channels throughout the basin, the Wapato Reach and, potentially, the floodplain reaches below Horn Rapids).

7.2 Understanding Key Factors Affecting Survival

In recent years our ability to track anadromous fish survival through multiple life-stages has improved dramatically. This makes it possible to determine the effects of specific habitat conditions on specific life stages. Currently PIT tags inserted at Yakama Nation smolt traps run in Satus, Toppenish, and Ahtanum creeks are the primary source of data on survival rates for smolt and adult life stages. Expanding the use and monitoring of PIT tags and other developing tagging technologies will help us make significant strides in understanding factors affecting survival rates and how those can be addressed via targeted recovery actions.

7.2.1 Role of Life-Cycle Models

Life-cycle models help us quantify how habitat conditions and other variables affect fish populations. Currently the most developed model in the Yakima Basin is the EDT model used in subbasin planning (See Appendix B). These models should be used to identify and evaluate working hypotheses about the effects of specific environmental conditions on survival and abundance of steelhead. Model results can then be used to help set restoration priorities and design management experiments that empirically test model assumptions.

7.2.2 Separating In and Out-of-Basin Survival Rates

To understand the interplay between in-basin and out-of-basin effects in determining the viability of Yakima steelhead populations requires tracking trends in out-of-basin survival rates. The smolt-to-adult return rate (SAR) reflects all agents of mortality affecting the life cycle of salmon and steelhead from migrating smolts through returning adults. There needs to be a way of counting smolts leaving the Yakima Basin each year and then the number of adults returning to the basin from that year's outmigration. The expanding network of PIT-tag detectors within and outside the Yakima Basin now enables us to count PIT-tagged outmigrants and returns. Currently we can estimate SARs for the Satus and Toppenish populations and the Ahtanum component of the Naches population. PIT tagging Upper Yakima and Naches steelhead would help us develop SARs more representative of the Yakima steelhead MPG.

7.2.3 Impacts of Mainstem Conditions on Smolt Survival

A key uncertainty that needs to be addressed is the relationship between flows, habitat conditions, and outmigration timing and survival. Steelhead data are limited, but work is being done based on more extensive PIT tag data and other monitoring of spring Chinook. Developing a more detailed understanding specific to steelhead will inform efforts to improve flow conditions during the spring outmigration and manage habitat in a manner that enhances outmigrant survival. This work should also focus on how refugia associated with in-stream diversity and side channel/floodplain habitats in the lower mainstem contribute to smolt survival. Survival rates through bypass systems associated with major irrigation diversions (Chandler, SVID, and WIP) should also be studied in order to identify if changes can be made to associated infrastructure that would improve passage conditions.

7.2.4 Impacts of High Delivery Flows on Juvenile Rearing

A key uncertainty identified in this plan is the effect on steelhead growth and survival of high summer delivery flows in general and the flip-flop flow regime in particular. Research and monitoring that improves our understanding of these impacts and tracks responses to any changes in delivery flow regimes implemented as part of recovery efforts will be critical. A review of past work on this topic and specific proposals for future research will be included in the RME plan under development.

7.2.5 Factors Affecting Upmigrating Adults

Factors that affect adult spawner survival and condition between passage at McNary and spawning are poorly understood. As detailed in Section 2.5.1.1, current flow and temperature conditions preclude migration into the basin from July until September. PIT tag detections and water temperature data suggest that steelhead hold in McNary pool. Understanding how this change in run-timing and holding habitat affects eventual survival and reproductive success will help guide recovery efforts. No actions recommended in this recovery plan are anticipated to significantly reduce average Columbia mainstem summer temperatures during that time period, although changes in

flow regime may lengthen the period of cooler temperatures in the lower Yakima River. Additional research and monitoring would help determine if targeted efforts to improve specific habitats and create relatively small-scale temperature refugia would improve spawner survival and condition. In addition, as noted in Section 2.5.1, recent data indicates that a portion of steelhead returning to the Yakima continue significant distances up the Columbia before returning downstream and entering the Yakima. Additional monitoring and research is needed to understanding the rates, causes, and implications of these upstream movements.

7.2.6 Resident/Anadromous Interactions

Understanding the interplay between resident and anadromous life histories of *O. mykiss* in the Upper Yakima and Naches populations will help ensure that appropriate goals are set for these populations and that recovery actions are effectively targeted to increase the abundance of steelhead. Research on this topic is currently ongoing and has received new impetus as a result of the listing, formulation of this recovery plan, and work on the Steelhead Master Plan by YKFP. Elements that need additional study include the:

- Genetic differences (if any) between individuals that exhibit anadromy and those that exhibit residency, including examination of subpopulation structure and genetic diversity of the population as a whole
- Effects of habitat conditions and competitive interactions on growth and condition of juvenile *O. mykiss*, and the impact of those patterns on subsequent smoltification or maturation as resident fish
- Population response to newly re-opened habitat from the standpoint of genetic processes and life history diversity
- Role of resident *O. mykiss* in determining the viability of the anadromous form

7.3 Understanding Habitat Trends and Threats Criteria

To address the delisting criteria, NOAA Fisheries is developing—as part of the Middle Columbia Steelhead Recovery Plan—new and existing monitoring and research to assess regarding habitat status and trends, which will need to be integrated into individual recovery plans. An inventory of existing efforts and specific proposals designed to fill gaps will be incorporated into the RME plan under development by the Yakima Basin Fish & Wildlife Recovery Board.

7.4 Evaluating Recovery Action Effectiveness

Effectiveness monitoring is needed to understand the nature and rate of response of habitat conditions and steelhead populations to specific recovery actions. Effectiveness of recovery actions will be monitored using a variety of approaches, including the Before-After-Control-Impact (BACI) design with stratified random sampling described in the Comprehensive Statewide Monitoring Strategy (ISP 2000; Washington State Monitoring Oversight Committee 2002), the Intensively Monitored Watershed Program promoted by

NOAA Fisheries and the Washington Monitoring Forum, and the SRFB Statewide Effectiveness Monitoring Program developed by Tetra Tech Inc. Supplementation actions will continue to be monitored according to the Yakima/Klickitat Fisheries Project (YKFP). Not all recovery actions recommended in this plan need to be monitored for effectiveness, but a sufficient number of replicates of each type of action should be assessed. This work will need to engage ecologists, fish biologists, geologists, hydrologists, and other experts familiar with the region.

Even if all habitat actions could be implemented immediately, which they cannot, there will be delays in the response to actions. Populations will likely respond more quickly to some actions (e.g., diversion screens and barrier removals) than they will to others (e.g., riparian plantings). Targeted monitoring and research will help resolve remaining uncertainties about the effects of recovery strategies on population VSP parameters. This work should focus on the linkages between physical and biological processes so managers can predict changes in survival and productivity in response to selected recovery actions. It will need to address the interactions between multiple recovery actions and their broader ecological context. Work should integrate system models and their underlying hypotheses whenever possible.

Specific topics to be addressed include the:

- Impacts of large woody debris on steelhead rearing, spawning, and incubation conditions
- Long-term effectiveness of the kelt reconditioning program
- Response to reopening suitable habitat
- Response to improvements in channel, floodplain, and riparian conditions

7.5 Understanding Critical Ecological Dynamics

Steelhead exist within a complex ecological setting, and their fate is affected by competition with other species, predation, nutrient cycling, the presence of contaminants and vegetation dynamics. Understanding these diverse factors will improve recovery efforts.

7.5.1 In-Basin Predation

Predation is one of the main factors driving juvenile survival. Research and monitoring is needed to track trends in predator populations, understand their impacts on steelhead, and develop appropriate management techniques to reduce predation.

Predation by bass and pikeminnow on outmigrating smolts is a concern, although it is believed to have a smaller effect on steelhead than other species because most steelhead smolts have left the lower Yakima River before smallmouth bass and northern pikeminnow become active. Monitoring to develop better estimates of piscine predation in the lower river should continue.

Avian predation is known to be significant, with known concentrations of terns and gulls in the lower Yakima River, mergansers throughout the basin, and increasing numbers of white pelicans and cormorants visiting the basin. Research and monitoring that improves understanding of trends in species presence, their impacts on steelhead, and how these impacts can be managed are vital. This should include efforts to understand the interactions between habitat conditions and predation and the impacts of specific infrastructure (e.g., irrigation diversion dams) that may facilitate predation. Detection of excreted PIT tags at sites where predatory birds congregate has helped in estimating consumption of salmonids in the Yakima and Columbia rivers. The Yakima/Klickitat Fisheries Project is currently tracking avian predation (Siegel and Fast 2006); this work should be continued and expanded.

7.5.2 Interspecies Effects

The Yakima/Klickitat Fisheries Project Species Interaction Study is a long-standing effort to understand how fish culture activities (hatchery supplementation of Chinook and coho stocks) affect other species, including steelhead (McMichael et al. 1999; McMichael et al. 1997; Pearsons and Hopley 1999; Pearsons et al. 1996). This project has increased our understanding of the ecological dynamics that affect both resident and anadromous *O. mykiss* in the basin and should be continued and expanded.

Two other sets of questions about interspecies interactions with management implications are:

- How increased interspecific competition in juvenile rearing areas may affect the balance between anadromy and residency for *O. mykiss*
- How the presence of exotic species affects steelhead recovery efforts, and how those species with significant impacts can be eradicated or controlled

7.5.3 Changes in Nutrient Transport

Anadromous fish bring oceanic nutrients inland when they die and decompose in headwaters and transport nutrients accumulated in growing juveniles from the headwaters to the ocean. Pre-1850 returns of salmon and steelhead are estimated to have ranged from 10 to 100 times current runs. The reduction in anadromous fish runs caused significant changes in these nutrient cycles. Effectively managing steelhead requires understanding how these changes affect growth and survival under current conditions, and what can be done to address nutrient limitations (e.g., adding carcasses and analogs). Restoring side channels and natural obstructions, such as woody debris may help retain carcasses in headwaters.

7.5.4 Expansion of Aquatic Vegetation

The lower Yakima mainstem has seen a significant increase in the presence of aquatic vegetation in the last decade. The expansion of water star grass in the lower 100 miles of the river is the most dramatic example. Once a relatively rare native plant, the star grass has expanded to cover much of the riverbed with thick mats of vegetation. This is

generally presumed to have been a response to the significant reduction in turbidity in the lower river over the last decade associated with improved quality of irrigation return flows. Effects on steelhead smolts and returning adults are unknown; the most likely impact is reduced habitat quality in the later part of the smolt outmigration and the early part of the adult immigration due the reduction in dissolved oxygen concentrations associated with star grass respiration. The South Yakima Conservation District's Eutrophication Study (Marie Zurowski, personal communication, 2007) has found that the relationship between vegetative growth and nutrient concentrations is complex. Understanding the factors that drive the spread of aquatic vegetation (increased light penetration and high nutrient concentrations) and those that limit it (scouring in flood events, high turbidity) will help managers respond. The Benton Conservation Districts conducting pilot work on control of water star grass.

7.5.5 Impacts of Pesticides and other Toxins

Agricultural lands in the Yakima Basin support a diversity of crops and more than 180 different pesticides are applied yearly in the basin (Rinella et al. 1999). Some widely used pesticide classes are known to interfere with the normal function of the nervous system in salmon and other fish, including the organophosphates (Beauvais et al. 2000; Brewer et al. 2001; Moore and Waring 2001; Morgan and Kiceniuk 1990; Scholz et al. 2000), the carbamates (Little et al. 1990; Waring and Moore 1997), the pyrethroids (Little et al. 1993; Moore and Waring 2001), and the triazines (Moore and Waring 1998; Saglio and Trijasse 1998). Many pesticides are known to interfere with the behavior or physiology of salmonids at concentrations well below lethal levels and within the range of exposure conditions that have been observed in the Yakima River and its tributaries (Cuffney et al. 1997; Ebbert and Embrey 2002; Joy and Patterson 1997; Morace et al. 1999; Rinella et al. 1999). Sublethal exposures to these chemicals may impair the neurochemistry, neurophysiology, or behavior of exposed salmonids. Recent research has also focused attention on the potential impacts of other contaminants on salmonids, including estrogens and other hormones. The effects of all of these contaminates on steelhead population VSP parameters in the Yakima Basin remain unknown, but the potential effects are significant and merit careful attention.

7.6 Understanding Impact of Long-Term Trends

Yakima Basin steelhead recovery will not happen under static conditions; rather their survival will occur within a dynamic human and climatic context. Understanding future trends in these areas is important.

7.6.1 Global Warming Impacts

There is broad consensus that worldwide climate is warming. Projections global warming impacts on the Pacific Northwest generally agree that there will be less snowpack accumulation and increased summer temperatures. Changes in precipitation are less certain with some models calling for increases and others for decreases. Research efforts are currently underway to understand how this will affect salmonid habitat in the Inland Columbia Basin (Beamish 1995; ISP 2002; 2002; 1989) and the Yakima Basin (Climate

Impacts Group 2009; Mastin 2008). Research will be vital to assuring that recovery efforts create real and sustained long-term improvement in habitat conditions.

7.6.2 Future Growth Impacts

In the last 150 years the landscapes and lifeways of the Yakima Basin have been transformed repeatedly, and such transformations will inevitably continue. Almost all projections for the Yakima Basin call for continued population growth. It is critical that proponents of steelhead recovery in the Yakima Basin anticipate how population growth and accompanying lifestyle decisions can be guided to protect fish habitats, local economies, and human quality of life.

7.7 Coordinating Research and Monitoring Efforts

The Yakima Basin is home to a wide range of long-term monitoring and research efforts, and the technical capacity within the basin and among out-of-basin partners actively engaged in the basin is impressive. Monitoring and research associated with steelhead recovery should be built upon these established resources. Extensive coordination will be required to ensure that existing resources are used effectively and that new resources are brought to bear in a targeted fashion that minimizes costs. The Yakima Basin Fish & Wildlife Recovery Board is currently working with partners in the basin to develop a working group focused on steelhead monitoring and research needs. Initial meetings have focused on understanding how data from current monitoring illuminates steelhead population trends and how gaps in current efforts can be filled to better track key VSP parameters. The hope is that this working group will coordinate and research and monitoring related to steelhead recovery plan efforts.

Currently, the YKFP is the dominant fish management monitoring and research organization for the Yakima Basin. The co-managers, Yakama Nation, and WDFW, develop monitoring and evaluation objectives and tasks through a joint process. The YKFP monitoring and evaluation program is organized into four categories: Natural Production, Harvest, Genetics, and Ecological Interactions. The co-managers' Science/Technical Advisory Committee employs the services of a work committee of scientists, the Monitoring Implementation Planning Team, to develop a Monitoring and Evaluation Plan (Fast and Sampson 2004). Although the YKFP's greatest monitoring emphasis has been on the targets of current YKFP supplementation efforts (spring Chinook, fall Chinook, and coho), the program also provides valuable information on steelhead. Steelhead out-migration is enumerated at Prosser Dam, steelhead have been a subject of YKFP species interactions studies, an EDT model has been developed for Yakima Basin steelhead, and a YKFP steelhead master plan is under development. YKFP also works with the Columbia River Inter-Tribal Fish Commission on the Yakima subbasin kelt reconditioning study and with the BOR on recent steelhead radio-tagging work in the upper Yakima River. Research and monitoring related to steelhead recovery should build upon the capacities of the YKFP program.

7.7.1 Integration with Regional Monitoring Programs

In the last five years, numerous regional monitoring initiatives have been developed, including the:

- Pacific Northwest Aquatic Monitoring Partnership
- Collaborative Systemwide Monitoring and Evaluation Project (CSMEP; administered by the Columbia Basin Fish & Wildlife Authority)
- Integrated Status and Effectiveness Monitoring Program (ISEMP) led by the NOAA Northwest Fisheries Science Center
- Washington Monitoring Forum (previously the Governor's Monitoring Forum)

Specific guidance documents that have been developed to guide monitoring related to recovery efforts include:

- Adaptive Management for Salmon Recovery: Decision Framework and Monitoring Guidance developed by the NOAA Northwest Fisheries Science Center (NMFS 2007)
- The Washington comprehensive monitoring strategy for watershed health and salmon recovery (ISP 2000; Washington State Monitoring Oversight Committee 2002)
- Governor's Forum On Monitoring, Recommendations to the Salmon Recovery Regions (GSRO and NMFS 2005)

Research and monitoring activities in the Yakima Basin will draw on the strategies, indicators, and protocols developed in these programs and documents in order to assure the use of valid sampling and statistical designs and consistent protocols and data management systems.

7.7.2 Out-of-Basin Research Needs

Long-term efforts to increase the survival of Yakima Basin steelhead will benefit from the broad range of monitoring and research already focused on the mainstem Columbia, its estuary, and the ocean. The efforts to better track out-of-basin survival for Yakima steelhead described in Section 7.1.4 will help connect the general work done out-of-basin with the specific impacts on Yakima Basin populations. Monitoring efforts in the basin should be coordinated with efforts outside of the basin; for example fish tagged in-basin can also provide valuable information on Columbia River and ocean survival. Specific research and monitoring efforts that will benefit Yakima Basin steelhead include those that focus on:

- Harvest rates of naturally produced steelhead and indirect mortalities associated with recreational and commercial fisheries in freshwater and ocean fisheries
- Fisheries management techniques that improve access to harvestable stocks while reducing undesirable direct and indirect impacts to naturally produced steelhead

- Interactions between hatchery and naturally produced steelhead in the mainstem Columbia and ocean, including possible density-dependent competition
- Hatchery programs' effects on the incidence of disease and predation on naturally produced fish
- Effects of upstream passage conditions in the Columbia River on the subsequent reproductive success of steelhead
- Factors that affect the survival rate of juvenile steelhead through the Columbia River dams
- Changes in predator prey relationships in the Columbia River, its estuary, and the ocean, and how they can be managed to increase survival rates for summer steelhead
- Factors that drive the variability in ocean conditions

8 Public Education and Outreach

8.1 Introduction
8.2 Education & Outreach Goals & Principles
8.3 Proposed Outreach Actions

8.1 Introduction

A key principle of the Yakima Basin Fish and Wildlife Recovery Board is that decisions regarding salmon recovery must occur within a transparent, inclusive, and collaborative process. This will require a strong public outreach program that informs and engages elected officials, federal, tribal, state, and local agencies, local interest groups, property owners, and the general public. Recovering steelhead in the Yakima Basin is by its very nature a long-term process that will require support and understanding from all of these parties. Without this support, recovery efforts will founder.

Every individual within the Yakima Basin directly or indirectly affects habitat functions essential to the survival of salmon on a daily basis. The most fundamental example of this is our daily consumption of water. Yet most of the public is not familiar with the complex and varied life cycle and habitat needs of salmonids or of the consequences to habitat functions and salmon populations of the choices we make in the daily pursuit of legitimate activities. Salmon recovery will require nurturing a broad understanding of these causes and effects.

Yakima Basin Environmental Education Project, WDFW, the Yakama Nation Fisheries and Wildlife, the USFS Respect the Rivers program, the Benton Conservation District Salmon in the Classroom program, and the Kittitas Environmental Education Network (KEEN) conduct salmon-recovery related outreach efforts in the basin. All of these efforts are to be lauded, but they will need to be supplemented with targeted outreach that focuses specifically on salmon recovery needs. The following factors will need to be addressed:

- Population growth in the Yakima Basin exceeded 25% in the previous decade and is projected to grow 45% more by 2020. Outreach to new residents to explain salmon recovery efforts will be an ongoing need.
- The information and education components of federal, state, and local programs have been drastically reduced over the past five years due to overall budget reductions. Rather than hiring full time personnel to develop and deliver public education, these functions are commonly added to existing staff's responsibilities.
- Agencies and personnel are largely "siloed," meaning there is very little knowledge, much less communication, about public education and outreach activities across agencies. The partnering that does occur is essentially dependent on a small cadre of highly energetic people who go above and beyond their required job responsibilities. The silo effect also occurs within large agencies. This is partly the result of information and education being dramatically reduced,

leaving staff to focus on public comment, and participation activities specific to regulatory requirements.

- Messaging tends to be narrow, focusing on the most critical issues facing an agency or group or meeting a specific regulatory requirement, e.g., a public comment period.
- Scant evidence is available to suggest that the public is aware of specific salmon recovery projects, what they are achieving, and how these projects fit into the big picture.
- Existing programs require local governments and state agencies to regulate land use on private and public property. Local experience shows that land use controls are not widely accepted unless there is broad public agreement with their intent, application, and result. Land use controls are only effective in their application if the property owners understand the purpose and support the limitations imposed on their range of land use activities. Outreach efforts can foster the dialogue and understanding required for existing programs to be implemented in an equitable and effective manner.

8.2 Education and Outreach Goals and Principles

Education and outreach efforts proposed in this plan should be characterized by:

- Close coordination with existing programs and entities, including the Yakima Basin Environmental Education Project (YBEEP) Conservation Districts, school districts, the USFS, local non-profit organizations, the WDFW, and the Washington State Department of Ecology
- Understanding that the future of the Yakima Basin be considered along with continued population and economic growth and that successful salmon recovery be a community-wide effort
- Recognition that salmon recovery efforts depend on voluntary efforts built on transparent processes and outreach to property owners and other stakeholders

8.3 Proposed Outreach Actions

The following list of proposed outreach actions will serve as a starting point for the Yakima Basin Fish & Wildlife Recovery Board's efforts to develop and coordinate a basinwide salmon recovery outreach strategy.

8.3.1 Short-Term Recovery Board Outreach Actions

Initial efforts by the Board will include:

- Summarizing existing education programs and materials in the basin
- Reformulating the education and public involvement committee developed during the Subbasin Planning Process in 2002-5

- Developing an education plan that targets specific audiences (school system, permit applicants, decision-makers, etc)
- Maintaining access to, and transparency of, all Board processes and programs, including regular meetings, special workshops or hearings and products developed by the Board
- Preparing and distributing newsletters and other regular updates on the Board's activities
- Developing a web page that provides the history of salmon recovery efforts in the basin, a calendar of board and committee meeting times, access to educational materials, access to planning and implementation documents, and access to current research
- Developing tools, such as display boards and PowerPoint presentations that staff can use at a variety of public gatherings, including county fairs or stakeholder group meetings, to explain activities and opportunities
- Working with county conservation districts, federal, tribal, and state resource agencies, water purveyors, school districts, and others to identify opportunities to leverage resources in a way that brings educational materials and learning opportunities directly to classrooms, landowners, recreationists, and other target audiences

8.3.2 Stakeholder Group Presentations

The subbasin planning board was very successful in scheduling and presenting information to stakeholder groups. In general, presentations were provided in PowerPoint format. By going directly to the meetings of stakeholders, two critical outcomes occurred. First, they reached a much broader audience; had a series of public meetings been held, perhaps a single representative of an organization would attend. At the organization's own meeting, many more individuals were reached directly. Second, going to "their turf" significantly changes the social dynamics. Individuals and groups believe they are being given greater respect, and they are more comfortable asking questions and sharing perspectives within their "natural setting." It is recommended that a round of stakeholder presentations be given each year. This can be done as part of a) releasing an annual report, b) soliciting review of or announcing the release of study or plan, or c) part of preparing and soliciting feedback on the annual work plan.

8.3.3 Newsletter/Annual Report

The Yakima Basin Fish & Wildlife Board should develop a newsletter/annual report, either on its own or in conjunction with other organizations. The newsletter should describe Board activities and give an overview of salmon recovery efforts throughout the basin. The newsletter should be sent to a broad-based mailing list, be posted online, and be available in hard copy at select public locations.

8.3.4 Project Tours

Even those who are actively engaged with salmon recovery issues often have only limited knowledge of on-the-ground projects. Project tours can help build this connection. A schedule of project tours should be developed and targeted at key audiences. Tours should provide both a general overview of recovery board efforts and project-specific information. “Virtual tours” based on photos taken in the field can be developed and made available on-line.

8.3.5 Posters and Handouts

Posters, brochures, and other handouts related to salmon recovery should be developed at made available in diverse public settings.

8.3.6 Workshops and Conferences

Workshops can cover a broad range of possible subject matter and can be developed to address the needs of specific groups. A conference held annually or every 18 months may also help link stakeholders, elected officials, and natural resource managers; possibilities for coordinating this with the annual Yakima Basin Science and Management conference should be investigated.

8.3.7 Mailing to Shoreline Landowners

One proposed outreach strategy is to send an *informational letter or brochure* to all shoreline property owners from each City Council or Board of County Commissioners. The letter or brochure would provide information on the biological, physical, and habitat values of the natural shoreline and the importance of those functions for water supply, water quality, shoreline stability, flood protection, and fish and wildlife habitat. The letter would inform owners that the natural condition of the shoreline is a State interest and the county/city have policy and codes required by the state legislature that regulate actions along the shoreline in order to protect those functions. It should include information on what property owners can do if they are losing shoreline to erosion and/or want to re-establish natural shoreline vegetation. It should note that the state and federal governments (including BPA) are spending millions of dollars per year in the Yakima Basin to recover a salmon fishery for the benefit of all basin interests and that this expenditure is wasted if actions by individual landowners result in the degradation of shorelines.

8.3.8 Create “Stream Stewards” Positions

This proposal calls for hiring a Stream Steward for each Watershed Resource Inventory Area (WRIA) or County within a basin that would be jointly funded by city, county, state and federal agencies. Possible roles of the steward would be to:

- Provide biological and technical assistance to local governments for projects, planning processes and reviews that involve shoreline habitat issues.

- Assist shoreline property owners interested in preserving natural habitat conditions or that have shoreline issues (erosion or bank protection).
- Act as a liaison between landowners, project proponents, and the local planning permitting/planning offices.
- Serve as a liaison between landowners and the Lead Entity application process for Salmon Recovery Funding Board funding.
- Be a resource for local non-profit organizations (e.g., greenways, land trusts).
- Be a classroom resource for elementary school teachers building shoreline/fish issues into curriculum.

APPENDIX A: Local Review of ICTRT Habitat Model

A.1 Overview of Review of ICTRT Intrinsic Potential Model

This appendix summarizes the results of local reviews of the Interior Columbia Technical Recovery Team (ICTRT)'s Intrinsic Potential Analysis for Middle Columbia River Steelhead in the Yakima Basin. The ICTRT developed a GIS-based model of habitat potential for steelhead that was used to estimate the historically available extent and quality of steelhead spawning and early rearing habitat. For more information on the development of the model and its use in ICTRT viability assessments for steelhead populations, see ICTRT (2007b), especially Appendix C.

As part of developing the Yakima Steelhead Recovery Plan, local biologists reviewed the areas identified as potential habitat by the ICTRT's GIS model. David Lind conducted the reviews for the Satus and Toppenish creek watersheds with the assistance of Tim Resseguie. Both are fish biologists with the Yakama Nation. Richard Visser (WDFW), David Lind (Yakama Nation), and Joel Freudenthal (Yakima County) conducted the Naches and Upper Yakima Area reviews. Alex Conley of the Yakima Basin Fish & Wildlife Recovery Board coordinated the review process. Extensive use was made of correspondence with other colleagues and existing documentation, including current fish distribution records and the Historic/Potential Steelhead Habitat analysis conducted as part of the Conservation Commission Limiting Factors Analysis for the Yakima Basin (Haring 2001).

The model results provided by the ICTRT in November of 2006 identified a number of areas as potential steelhead habitat that the local review team did not consider to be or have been potential steelhead habitat. Several reasons were noted:

1) In a number of cases, the model did not include the presence of known natural fish passage barriers. The local reviewers identified these and documentation was provided to the ICTRT; most have been incorporated into the most recent version of the ICTRT model. They are noted in the population-specific discussions below.

2) The model consistently assigned habitat potential to streams in arid portions of the basin that the review team identified as not generating enough flow to support even limited use by steelhead. Correcting this would require refining the model's approach to predicating flow in arid (under 16") rainfall regimes. Inclusion of streams with watersheds that do not have the precipitation and/or watershed area to generate any sustained base flows was primarily an issue in the Satus Creek watershed and the lowest elevations in the Upper Yakima and Naches Watersheds. In areas with over 16" annual precipitation, the model performed much better, and largely matched local surveys and expert opinion. The ICTRT is exploring using additional data sources and analyses to exclude streams with insufficient stream flow from the habitat model, but has not incorporated these into their model at the time of this writing. In the current drafts of the Yakima

MPG Stock Status reports the ICTRT does acknowledge this limitation to their model, and notes the areas excluded in the local review.

3) In a few instances, drainages that would not have generated enough flow to support even limited use by steelhead prior to European settlement currently convey return flow from irrigation systems. Some of these areas may have potential to produce steelhead (Romey and Cramer 2001), and some level of use by salmon and *O. mykiss* is known to occur (Monk 2001) even though they would not have served as habitat prior to irrigation development. These areas should not be included in assessments of historic habitat, and were identified as "sustained by return flows" by local reviewers. In the current drafts of the Yakima MPG Stock Status reports the ICTRT does acknowledge this limitation to their model, and note the areas excluded in the local review.

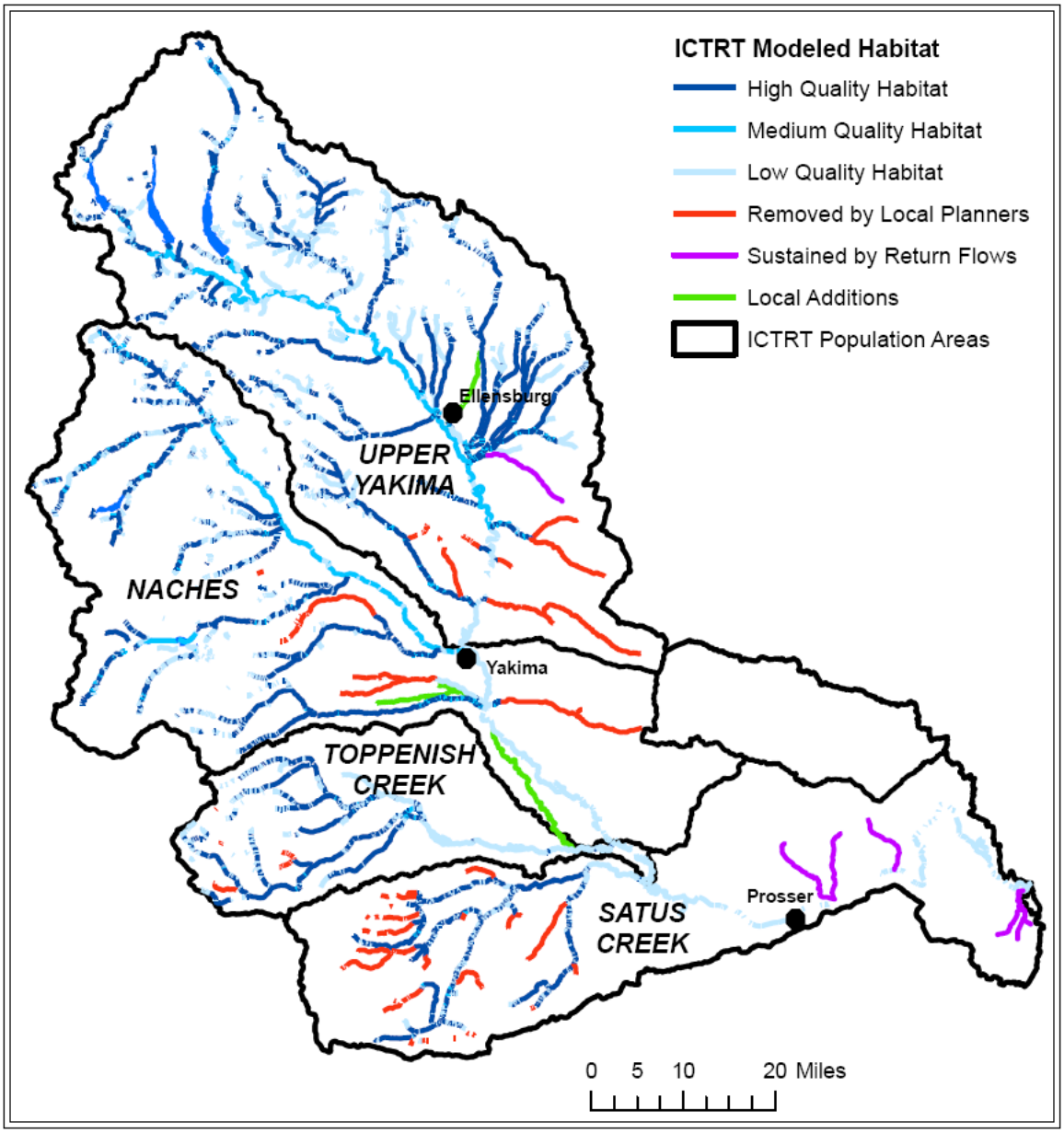
4) Local reviewers expressed concern that the identification of all of the lower Yakima mainstem as potential spawning and early rearing habitat risked biasing the estimate of available habitat. In response to these concerns and similar ones raised in other areas, the ICTRT developed an analysis based on channel morphology that specifically identifies mainstem areas with spawning potential. This analysis is based on analysis of the location of documented spawning in the Okanogan and Wenatchee rivers. The most recent versions of the ICTRT model incorporate this analysis; the areas it identifies as having spawning potential correspond better with local assessments.

The model consistently extended small extents of lower quality habitat higher up small tributaries and into headwater reaches than locally derived maps of current distributions, but these differences do not make significant differences in overall population-level weighted habitat area, and were considered as feasibly within historic potential by local reviewers.

The model also failed to include a few streams considered by the review team to be potential/historic habitat. In all of these cases the streams were either part of split channels connected to other streams at both upstream and downstream ends, or small spring fed creeks in floodplains. The ICTRT model routed flows down a single channel where channels diverged or did not recognize the streams as having sufficient watershed area to generate flow. The ICTRT has recognized these limitations to their model, but has not added these areas. These areas are limited in extent and are not identified as key areas for restoration, and their exclusion does not have any significant effects on the results of the ICTRT viability analysis.

Overall, the current revised version of the ICTRT Intrinsic Potential Analysis' identification of potential steelhead habitat is a credible broad-brush estimation of the historic and potential habitat accessible to steelhead in the Yakima Basin. The ICTRT analysis or the locally revised analysis should not be used to classify specific areas and their current habitat values and/or potential at a reach or project level.

Figure A.1: July 2007 ICTRT Intrinsic Potential model with local adjustments



A.2 Satus Population Area

Based on our initial review, the ICTRT model significantly overestimated potential steelhead habitat in the Satus Creek watershed. There were two main reasons: 1) several natural fish passage barriers not included in the model, and 2) the inclusion of numerous streams with no sustained base flows, only limited runoff in wet periods, and steep canyons with very little to no developed floodplain. There is also one reach that local biologists believe is of significantly higher quality than indicated by the model.

1) Area above Satus Falls inaccessible per David Lind, Yakama Nation Fisheries staff, 1/28/07) *Incorporated into 7/07 ICTRT model as Barrier*

2) Area above Logy Creek Falls inaccessible per David Lind, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier*

3) Area of Dry Creek inaccessible due to Gradient Barriers in both forks above confluence; also lack of baseflow flow above canyons (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier*

4) Several steep canyons without any sustained base flows, limited runoff even in wet periods, and little to no floodplain. In the few areas where floodplains exist in lower ends, ICTRT ratings were left intact to reflect possible historic potential, but are not deemed areas with any current potential (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Noted in updated text of ICTRT Satus Stock Status Report but not incorporated into GIS model; identified in red on* Figure A.1.

5) Smaller areas without any sustained base flows and limited runoff even in wet periods (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Noted in updated text of ICTRT Satus Stock Status Report but not incorporated into GIS model; identified in red on* Figure A.1.

6) Reach of mainstem Satus Creek considered high quality habitat for rearing (higher than adjoining areas given a higher rating) per David Lind, Yakama Nation Fisheries staff, 1/28/07. *Not incorporated into ICTRT products at this time.*

7) Adjustments to the designations of the mainstem Yakima based on the ICTRT analysis discussed in A.1, # 4 above. *Revised analysis of lower mainstem incorporated into 7/07 ICTRT model*

This local adjustments described here significantly reduce the amount of habitat available in the Satus Creek Population Area (see Table 2.2) but do not change the ICTRT-designated size class for the population.

A.3 Toppenish Creek Steelhead Population

Generally, the model performed much better in Toppenish Creek, which has a less dendritic drainage structure and more precipitation than the Satus population area. There was some overestimation of habitat due to 1) inclusion of a few smaller tributaries local biologists did not identify as potential steelhead habitat due to flow limitations and 2) extension of habitat beyond known barriers. These were addressed as follows:

1) White Deer Creek has habitat that supports resident rainbow trout, but the steep canyon reach near the mouth precludes use by steelhead (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier.*

2) Area inaccessible due to Agency Creek Falls (ID#4 in YN Barriers Shapefile) per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Incorporated into 7/07 ICTRT model as Barrier.*

3) Area of steep canyons without any sustained base flows, limited runoff even in wet periods, and little to no floodplain (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on* Figure A.1.

4) Tributary to South Fork of Toppenish Creek is inaccessible due to Gradient Barrier (per David Lind and Tim Resseguie, Yakama Nation Fisheries staff, 1/28/07). *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on* Figure A.1.

5) Miscellaneous isolated habitat patches in areas not considered potential habitat (per David Lind, Yakama Nation Fisheries staff, 1/28/07). *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on* Figure A.1.

6) There is also one habitat addition proposed here; the tail end of Wanity Slough enters into lower Toppenish Creek, and any fish using the slough are likely to be of Toppenish origin, even as geographically the Slough is mainly in the Naches population area. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on* Figure A.1.

The adjustments made by local reviewers have very little affect on the total area and spatial distribution of the Toppenish population, and have no effect on the ICTRT viability analysis results.

A.4 Naches Population Area

Generally, the model performed quite well in the Naches Population Area. Local reviewers identified 1) barriers that were added to the model, 2) three areas that the local review team as having insufficient flows to be identified as habitat, and 3) five areas where the local review team felt that habitat with potential for steelhead had not been included in the model.

Local reviewers identified a number of natural barriers that had not been originally identified by the ICTRT. These were compiled from 1) WDFW's natural barriers coverage (from Brian McTeague), 2) consultations with Jim Cummins, Eric Anderson (fish biologists with WDFW in Yakima), and Yuki Reiss (fish biologist for the Naches Ranger District of the Wenatchee National Forest). These are:

1) Union Creek Falls (total passage barrier, on map). Incorporated by ICTRT; Fall # 470 in ICTRT yrbbarr shapefile.

2) Steep Canyon/gradient barrier on Kettle Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 469 in ICTRT yrbbarr shapefile.

3) 50' falls on Deep Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 468 in ICTRT yrbbarr shapefile.

4) Falls/gradient barrier on Copper Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 466 in ICTRT yrbbarr shapefile.

5) Falls on NF Rattlesnake Ck per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 467 in ICTRT yrbbarr shapefile.

6) Impassable falls in Hindoo Creek per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 465 in ICTRT yrbbarr shapefile.

7) Falls on Oak Ck mapped by WDFW; confirmed by Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 237 in ICTRT yrbbarr shapefile.

8) S. Fork Tieton Falls (50') per Jim Cummins & Eric Anderson & USFS staff. Partially incorporated by ICTRT; Fall # 462 in ICTRT yrbbarr shapefile.

9) Bear Ck Falls (40') per Jim Cummins & Eric Anderson & USFS staff. Incorporated by ICTRT; Fall # 261 in ICTRT yrbbarr shapefile.

10) SF Cowiche Ck barrier falls per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 463 in ICTRT yrbbarr shapefile.

11) Reynolds Creek barrier falls per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 464 in ICTRT yrbbarr shapefile.

12) Crow Creek barrier falls per Jim Cummins & Eric Anderson. Incorporated by ICTRT; Fall # 471 in ICTRT yrbbarr shapefile.

13) An isolated fragment in an Oak Creek Tributary was considered to be inaccessible to steelhead due to gradient and flow limitations in the canyon downstream. Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1.

The following areas were identified as having insufficient historic flows to be classified as steelhead habitat:

1) The upper portion of the North Fork of Cowiche Creek is an arid watershed with only limited intermittent flow. At the townsite of Cowiche there are several large springs, and the local review team concurred with the TRT designation from that point downstream. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1.*

2) The upper portion of the Wide Hollow Creek is an arid watershed with only limited intermittent flow. At 46th Street there are several large springs, and the local review team concurred with the TRT designation from that point downstream. There may be some increased potential above historic between this point and 96th St due to increased flows from irrigation return flows, but this does not apply above the forks. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1.*

3) Moxee Creek is an arid watershed with only limited intermittent flow (see discussion of arid creeks in the Upper Yakima section below); lower portions currently carry irrigation return flows. *Acknowledged in ICTRT Upper Yakima Stock Status Assessment but not incorporated into GIS model; identified in red on Figure A.1*.

There are five additions to the ICTRT-identified historic habitat that were identified by local reviewers:

1) Wanity Slough, which is the most prominent of the relic side channels of the Yakima River in the Wapato area. It is currently managed as an irrigation drain, but likely once served as steelhead habitat, and while a currently low priority for restoration, still has some potential. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on Figure A.1*.

2) Bachelor and Spring creeks in the Ahtanum Floodplain. These are historic side channels and/or spring fed creeks that were not identified as habitat by the model, but which would have historic/potential habitat value. Bachelor Creek is now managed as part of an irrigation delivery system and restoring flows to the Ahtanum Creek mainstem has been given much higher priority than work within Bachelor Creek. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on Figure A.1*.

3) Initial ICTRT model ended at a partial barrier on Crow Creek; the actual upper extent of fish access is further upstream. *Incorporated by ICTRT in the 7/07 model version.*

4) Initial ICTRT model ended at a partial barrier on the North Fork of Rattlesnake Creek; the actual upper extent of fish access is further upstream. *Incorporated by ICTRT in the 7/07 model version.*

5) Quality habitat extends ~1.5 miles upstream of the upper end of modeled habitat in Upper Rattlesnake Creek. *Not incorporated into ICTRT products at this time*.

The adjustments made by local reviewers have little affect on the total area and spatial distribution of the Naches population, and have no effect on the ICTRT viability analysis results.

A.5 Upper Yakima Population Area

In most of the Upper Yakima Population Area, model results were consistent with review team expectations, except where unidentified passage barriers exist. However in the lower elevations, the model consistently identified low rainfall areas that do not support sufficient flow as steelhead habitat. There is also one proposed addition to the model.

The three barriers were incorporated into the model based on local review:

1) Thorp Creek has a gradient barrier in lower end of creek as identified by BOR's Yakima Storage Reservoir Fish Passage Study. *Incorporated by ICTRT; Fall # 453 in ICTRT yrbbarr shapefile.*

2) The Cooper River has an impassable fall at RM 0.6 (identified by BOR's Yakima Storage Reservoir Fish Passage Study and Jeff Thomas, USFWS). *Incorporated by ICTRT; Fall # 452 in ICTRT yrbbarr shapefile.*

3) Coleman Creek Falls (identified by Kittitas County Conservation District Stream Assessment data & photo). *Incorporated by ICTRT; Fall # 472 in ICTRT yrbbarr shapefile.*

The arid areas identified as not having sufficient flows to support steelhead fall into two classes:

1) Selah, Lmuma, and Whipple Wasteway/Badger creeks all drain larger watersheds at low elevations on the east side of the Yakima Basin. Maps from the Eastern Washington Stormwater Manual[40] show these streams within a climatic region where there are only about two and a half months of the year where precipitation exceeds potential evapotranspiration, and where in most years the excess is fully absorbed by the soils. The local review team was willing to consider the lower end of Lmuma Creek as having some habitat potential, as it is the wettest of these creeks, with a small portion of its watershed extending into a 16" precipitation zone that is expected to produce some runoff in a typical year. *Noted in updated text of ICTRT Upper Yakima Stock Status Report but not incorporated into GIS model; identified in red on Figure A.1*.

2) Roza and two Lower Wenas Tributaries drain small arid watershed, do not have hydric soils or groundwater inputs and are often elevated on fans at their lower ends. The local review team felt these did not have the flow regime needed to support steelhead. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in red on Figure A.1*.

Areas identified as historic/potential steelhead habitat by local reviewers, but not included in the ICTRT model include Wilson Creek splits off from Naneum Creek and was likely historic habitat, though extensive passage barriers in and below Ellensburg preclude current use by steelhead. *Acknowledged in discussions with ICTRT but not incorporated into GIS model; identified in green on* Figure A.1.

Comment Regarding the Caribou, Reecer and Naneum MSAs. Numerous streams drain the hills around Ellensburg, with some arising in the arid foothills, and others extending higher into the forested zone. While the review team and the model both identified these as potential habitat, the relative productivity of streams in this area will be highly variable, with some reaches providing high quality habitat and others being marginal at best. Many of these streams are interconnected and have been incorporated into the irrigations systems. Efforts to restore fish passage and habitat in these areas are currently underway, and are being guided by prioritization efforts that carefully consider the historic potential of each waterway, current conditions and trade-offs associated with the interconnectedness of the stream system.

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[40] http://watershedpledge.org/biblio/0410076maps.html

The adjustments made by local reviewers have very little affect on the total area and overall spatial distribution of the Upper Yakima population. They do significantly reduce the habitat area in a few MSAs and MiSAs, but have no effect on the overall ICTRT viability analysis results.

APPENDIX B: EDT Model Results for Yakima Steelhead

B.1 Overview of EDT Estimates of Population Performance

The Ecosystem Diagnosis and Treatment (EDT) was developed by Mobrand Biometrics (now part of Jones & Stokes) to help managers estimate the responses of anadromous fish populations to changes in habitat conditions (Lestelle et al. 1996; Lichatowich et al. 1995; Mobrand Biometrics 1999; Mobrand et al. 1997). The EDT model has been used in the Yakima Basin since the mid-1990s and was a key element in the 2002-2004 Subbasin Planning Process. This section gives an overview of the most recent EDT results for the four Yakima Basin steelhead populations. More detail on the EDT model is available at the Mobrand website (http://www.mobrand.com/MBI/library.html).

The EDT model quantifies the biological response to environmental conditions by estimating several components of population performance, including equilibrium abundance, productivity and life history diversity. It should be noted that these numbers reflect the average performance of a population over duration of years and are not specific to a single year or generation. Though numbers produced by the model reflect "average conditions", the model does take environmental variability into consideration through space and time.

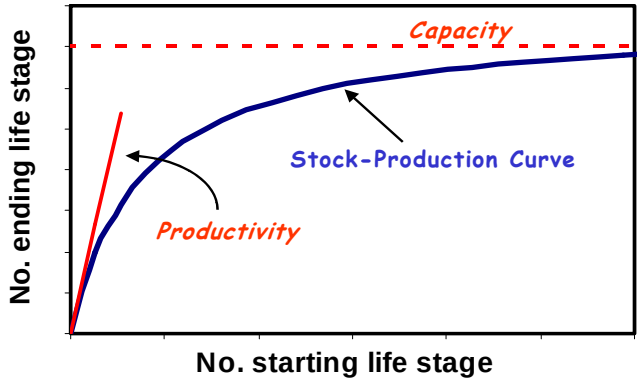
The Beverton-Holt stock recruitment function is foundational to the EDT model. The EDT model generates a unique stock recruitment function for each life stage by stream reach, which are all integrated to calculate population abundance and productivity (Figure B.1). The point where the stock recruitment curve intersects the replacement line defines the population equilibrium abundance. Productivity represents the density independent growth rate of a population and is expressed as the number of recruits per spawner. Productivity also represents the resiliency of a population or ability to endure catastrophic events while sustaining viable numbers. Life history diversity represents the proportion of successful life history pathways offered to a population through space and time. The diversity index indicates the variety of life history pathways offered to a population and is a buffering mechanism against catastrophic events that might occur at a somewhat localized scale and affect a proportion of a population. These population performance parameters indicate the long-term viability and sustenance of the targeted population.

To understand the kinds of information utilized and how it is applied, it is important to understand what the analysis aims to produce. Information is translated through the procedure to address two aspects of fish population performance: productivity and capacity. These two parameters define a theoretical stock-production (S-P) relationship, illustrated using a Beverton-Holt production function in Figure B.1. The S-P curve displayed here is an example of what a relationship might look like between the number of fish at the beginning of a life stage and those surviving to the end of the stage.

Productivity is equivalent to the concept of intrinsic productivity discussed in McElhany et al. (2000) to describe viable salmon populations with respect to the Endangered Species Act. It is survival without density dependence effects, i.e., the approximate rate that would occur when competition for resources among the population is minimal. In

Figure B.1, it is the slope of the S-P curve at its origin. Productivity is a function of the quality of the environment.[41] In contrast, environmental capacity limits how large a population can grow given finite space and food resources. Capacity is represented by the asymptote in Figure B.1 and controls the extent that density dependence is operative at different population levels. Capacity is a function of the quantity of key habitats and food resources available. Sets of rules are used by the EDT method to derive productivity, key habitat, and food parameter values from environmental information—these serve as inputs into the EDT model.[42]

Figure B.1: Example stock-production relationship



The EDT model predicts that the abundance of steelhead in the Yakima Basin declined by 83% to 95% due to the change from historic to current environmental conditions (Table B.1). According to the model, the Naches, Toppenish, and Upper Yakima populations exhibit reductions in life history diversity from 89% to 93% since pre settlement era. A common theme in the reduction in the diversity index centers around major blockages to fish passage in and out of headwater tributaries associated with dam construction. In conjunction with this, major tributaries that historically supported healthy steelhead populations were subject to significant surface water withdrawals and associated dewatered reaches, unscreened diversions and impassable obstructions. These overwhelming burdens not only reduced life history diversity, but also substantially reduced habitat capacity (Table B.1).

To some degree, the productivity values are indicative of the quality of available habitat offered to a population. Riparian corridors and flow regimes have remained relatively intact in the upper portions of Satus and Toppenish systems compared to the Naches and Upper Yakima portions of the basin. As a result, productivity values for Satus and Toppenish Creek steelhead are modestly higher than those of the Naches and Upper Yakima (Table B.1).

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[41] Productivity measured across a full life cycle also incorporates sex ratio, fecundity, and fitness.

[42] In EDT, food is both a component of environmental quality (thereby affecting productivity) and quantity (since food is assumed to affect both density-independent and –dependent mortality.) Regarding its role in affecting density-dependent mortality, the food parameter is used in conjunction with the key habitat parameter in estimating capacity.

Table B.1 Current and historic performance generated by EDT

Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Naches Steelhead	Current without harvest	10%	1.6	2,287	849
	Current with harvest	10%	1.6	2,287	849
	Historic potential	91%	10.4	16,092	14,542
Satus Steelhead	Current without harvest	38%	2.5	1,552	926
	Current with harvest	38%	2.5	1,552	926
	Historic potential	92%	10.3	6,382	5,761
Toppenish Steelhead	Current without harvest	13%	2.3	876	497
	Current with harvest	13%	2.3	876	497
	Historic potential	94%	8.8	5,234	4,639
Upper Yakima Steelhead	Current without harvest	6%	1.7	2,453	1,047
	Current with harvest	6%	1.7	2,453	1,047
	Historic potential	91%	10.6	23,355	21,152

Ladder diagrams produced by the model evaluate the degree to which restoration[43] and preservation of specific geographic areas will benefit a population. Geographic areas can be defined at a variety of scales from individual stream reaches up to an entire watershed, etc. For our purposes, geographic areas for streams other than the Yakima were primarily defined at the watershed and tributary scale depending on the size of the population. Upper and lower bounds of the Yakima mainstem geographic area were defined by a major tributaries or channel spanning structures such as diversion dams. Restoration and protection potential are generated for each geographic area and represent the potential increase or decrease in the population performance parameters.

B.2 Restoration Potential and Limiting Factors by Populations

Table B.2, Table B.3, Table B.4, and Table B.5 present the geographic areas where restoration actions would make the greatest contribution to increasing abundance, productivity and capacity. The tables include areas that together comprise 75% of the total restoration potential with respect to abundance. The numbers reflect the potential increases in each performance parameter and are expressed as potential gains relevant to the current performance of the population generated by the model. The combined ranking shows the significance of a specific geographic area for a population that is pertinent to restoring all three components of population performance.

The strategic summary diagrams (Figure B.2, Figure B.3, Figure B.4, and Figure B.5) summarize the major physical and biological components limiting production of the target population within each specified geographic area. These limiting factors are known as the level 3 survival factors and are generated from a suite of level 2 attributes. Level 2 attributes are defined by data inputs that characterize the physical and biological environment. A single level 2 attribute acts as the primary component upon the Level 3

[43] Restoration Potential as referenced in EDT ladder diagrams is a comparison of Historical condition minus Current condition. In many instances it is not feasible to realize the full restoration potential.

Survival Factor. All other related level 2 attributes act as modifiers upon the level 3, which ultimately defines productivity, abundance and diversity index (Lestelle et al. 2004). In a nutshell, the level 3 correlates represent the biological response to the fluctuating environmental conditions through space and time. Negative impacts on survival are integrated across all life stages for each level 3 correlate. In a qualitative sense, the strategic summaries illustrate the severity of a level 3 attribute upon productivity. The large, medium and small dots in the diagram correspond to the three ranges of severity.

B.2.1 Naches River Steelhead

Table B.2 indicates the geographic areas with the greatest restoration potential for the Naches steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.2 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area.

The Cowiche to Tieton reach is the geographic area that would increase the Naches steelhead population performance the most (+112.1% for abundance) if fully restored to historic conditions. Historically this was the largest floodplain in the Naches arm of the basin. Both currently and historically this geographic area is important for steelhead spawning and, summer and winter rearing. Due to the location of this geographic area in the basin, Naches steelhead spend one or more of their life stages within, stressing the importance of this geographic area. Unfortunately, because of extensive build out and placement of Highway 12 within this floodplain there is limited opportunity to fully realize its historic potential.

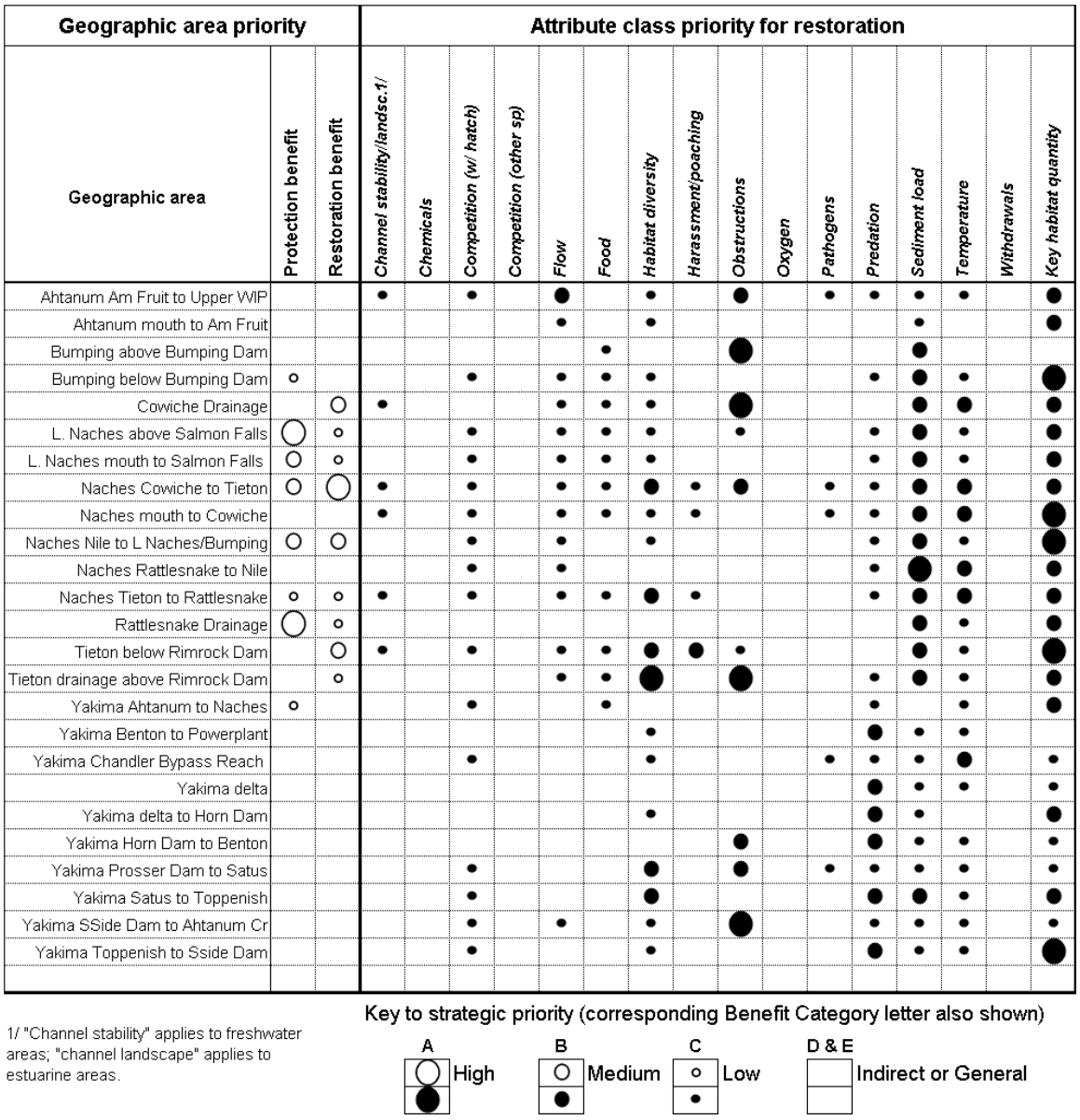
The model indicates the diversity index could be twice that of current life history pathways if the Cowiche drainage was fully restored). There have been major passage issues near the mouth of Cowiche that have severely reduced the life history pathways, productivity and abundance of the Naches steelhead population. Other degradations have occurred in the Cowiche geographic area in the form of increased temperatures, flow, sediment loads and habitat simplification.

Table B.2 Restoration geographic areas for the Naches steelhead population

Naches Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area					
Naches Cowiche to Tieton	1	124.5%	72.9%	23.7%	112.1%
Cowiche Drainage	2	100.0%	37.1%	8.2%	57.8%
Tieton below Tieton Dam	3	75.3%	35.0%	11.8%	61.0%
Naches Nile to L Naches/Bumping	4	63.7%	36.4%	4.8%	52.2%
Naches Tieton to Rattlesnake	5	73.1%	28.7%	5.5%	45.3%
L. Naches above Salmon Falls	6	54.9%	28.8%	4.1%	43.5%
Tieton drainage above Tieton Dam	7	41.2%	24.4%	24.5%	65.9%
L. Naches mouth to Salmon Falls	8	65.1%	21.8%	6.3%	38.5%
Rattlesnake Drainage	9	47.6%	28.4%	3.7%	42.6%
Yakima Prosser Dam to Satus	10	55.3%	7.0%	17.3%	30.3%
Naches mouth to Cowiche	12	13.7%	17.7%	4.1%	30.7%

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

Figure B.2: Major reach-level limiting factors for the Naches population



B.2.2 Satus Creek Steelhead

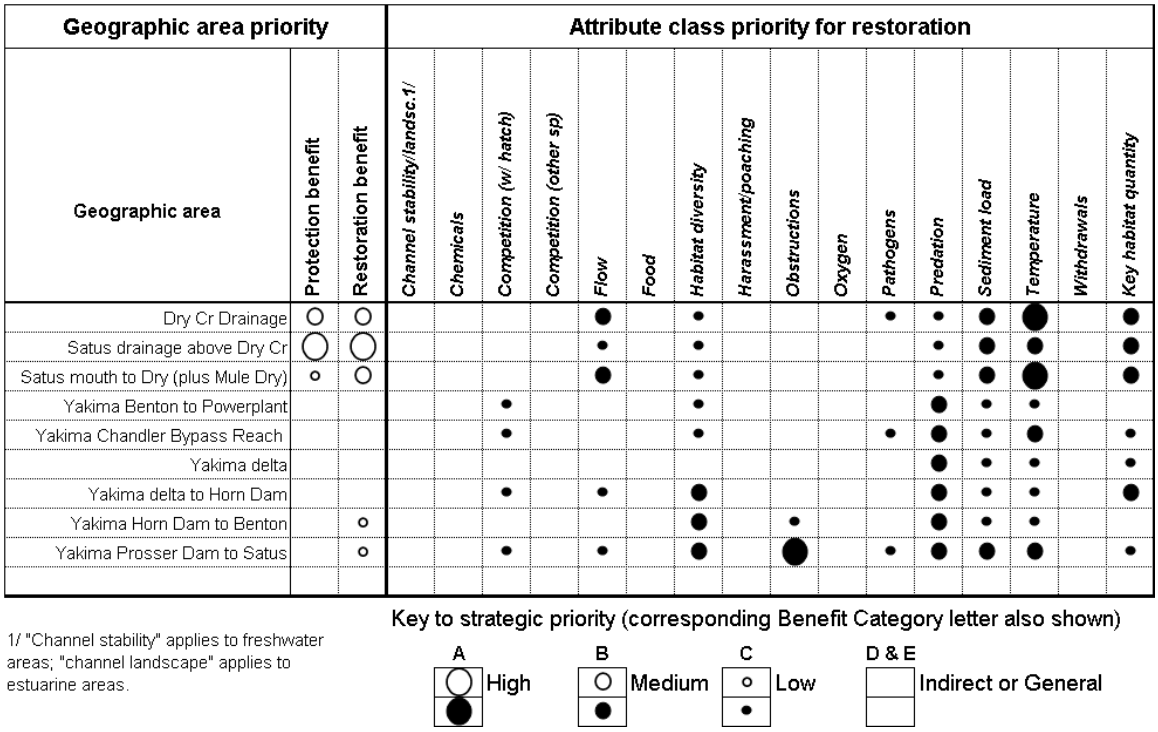
Table B.3 indicates the geographic areas with the greatest restoration potential for the Satus steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.3 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area.

Table B.3: Restoration geographic areas for the Satus steelhead population

Satus Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area					
Satus drainage above Dry Cr	1	30.6%	59.3%	30.2%	63.0%
Dry Cr Drainage	2	44.8%	21.7%	8.2%	21.2%
Satus mouth to Dry (and Mule Dry)	3	39.1%	14.8%	23.7%	34.4%
Yakima Prosser Dam to Satus	4	5.1%	11.5%	13.2%	21.1%

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

Figure B.3: Major reach-level limiting factors for the Satus Creek population



B.2.3 Toppenish Creek Steelhead

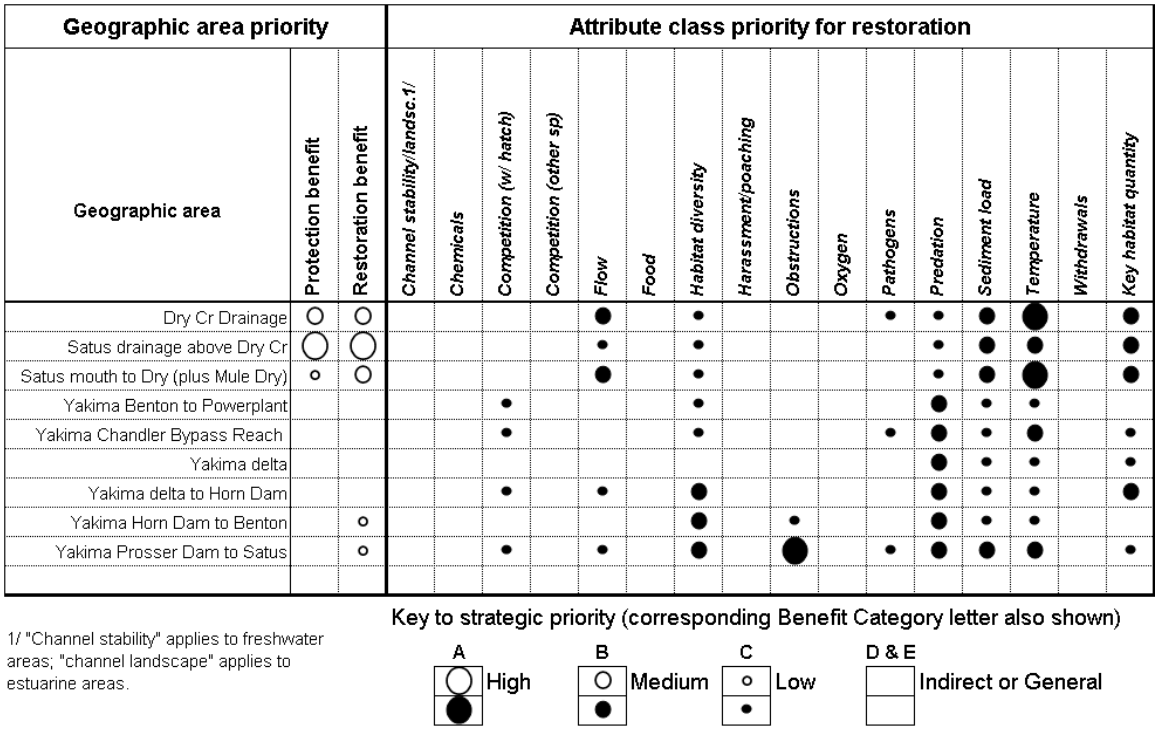
Table B.4 indicates the geographic areas with the greatest restoration potential for the Toppenish steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.4 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area.

Table B.4: Restoration geographic areas for the Toppenish steelhead population

Toppenish Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area:					
Toppenish Unit II to Lateral Canal	1	147.1%	12.3%	34.6%	45.8%
Toppenish above Lateral Canal	2	29.5%	14.0%	21.1%	32.5%
Yakima Prosser Dam to Satus	3	14.6%	14.1%	17.9%	29.1%
Simcoe drainage above Agency	3	97.1%	11.0%	16.8%	25.6%
Topp. mouth to Unit II Diversion	4	96.1%	2.3%	21.5%	23.5%

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

Figure B.4: Major reach-level limiting factors for the Toppenish Creek population



B.2.4 Upper Yakima River Steelhead

Table B.5 indicates the geographic areas with the greatest restoration potential for the Upper Yakima steelhead population. The table also shows the hypothesized potential gains in the performance parameters expressed as percentages increase with respect to current performance if one was to restore the geographic area back to pre settlement era conditions. Figure B.5 qualitatively illustrates the major level 3 correlates compounded across all life stages impacting survival in the specified geographic area. Before discussing the results it should be stated that there is disparity between the EDT predicted steelhead equilibrium abundance for the upper Yakima population and what has been observed for the past 10 years based on Roza Dam fish counts. The EDT model does not currently have the capability to segregate population performance parameters between the resident and anadromous life history forms of *Oncorhynchus mykiss*; and the upper Yakima population is largely comprised of resident rainbow trout. Revision of the model to address this issue is currently under discussion.

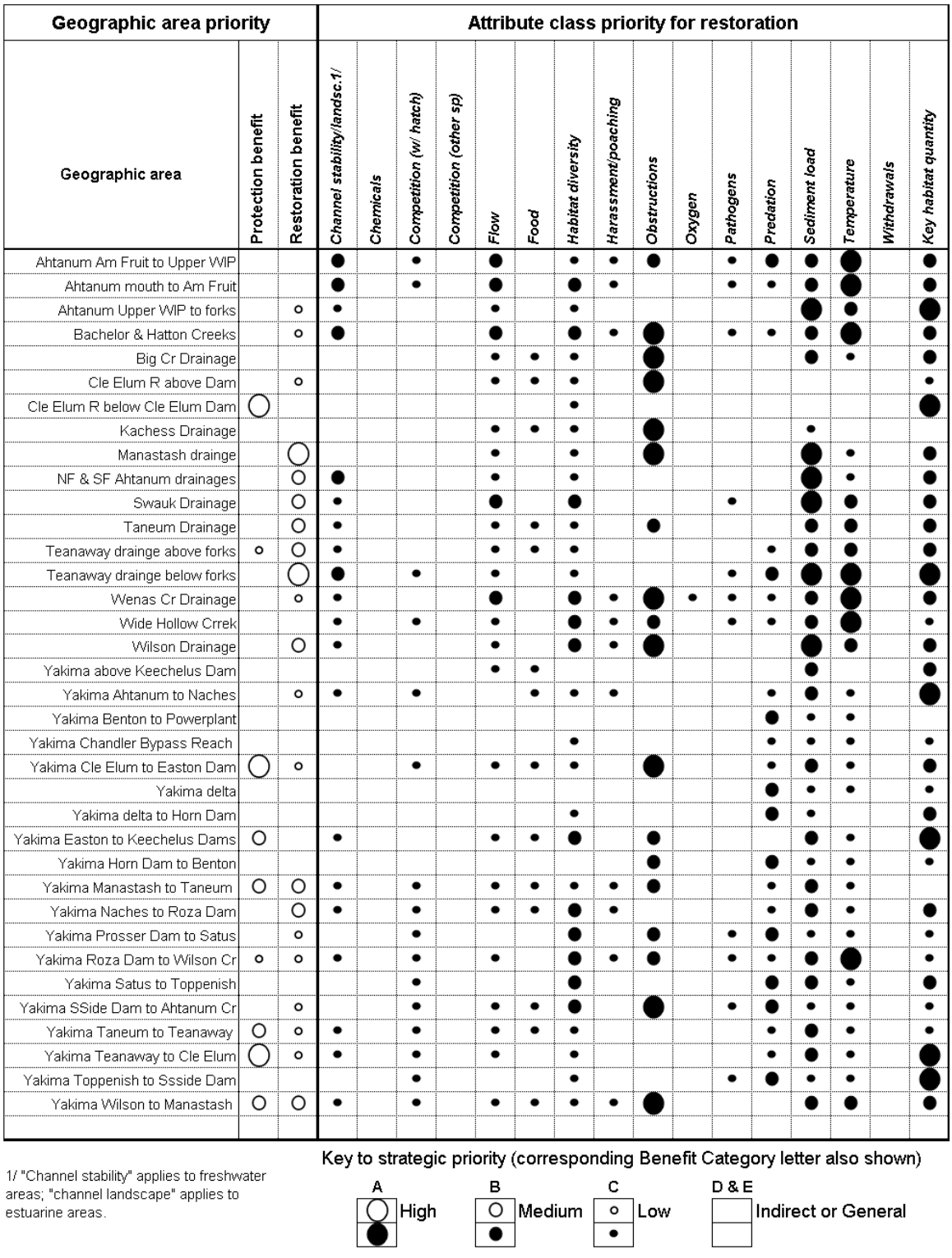
The upper Yakima steelhead population incorporates the largest geographic area of any of the basin steelhead populations. Not surprisingly 10 of the 15 geographic areas define tributary type watersheds suggesting the historical importance of tributary contribution to the upper Yakima population. This is illustrated by the fact that top three geographic areas were all major tributaries–Manastash, Teanaway (below the forks) and the Wilson drainage (which comprises many small tributaries).

Table B.5: Restoration geographic areas for the Upper Yakima steelhead population

Upper Yakima Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area:					
Manastash drainage	1	72.1%	68.1%	20.6%	86.2%
Teanaway drainage below forks	2	47.7%	57.6%	17.5%	75.2%
Wilson Drainage	3	188.3%	26.4%	19.8%	53.4%
Yakima Manastash to Taneum	4	41.4%	34.8%	4.4%	40.7%
Teanaway drainage above forks	5	113.8%	24.1%	8.8%	37.2%
NF & SF Ahtanum drainages	5	69.4%	28.8%	2.9%	33.7%
Taneum Drainage	6	38.7%	35.1%	3.8%	40.0%
Yakima Wilson to Manastash	7	40.5%	31.6%	4.1%	37.6%
Yakima Naches to Roza Dam	8	27.3%	30.5%	4.6%	37.5%
Swauk Drainage	8	43.5%	24.4%	3.3%	30.5%
Wenas Cr Drainage	9	54.7%	19.0%	7.0%	29.9%
Cle Elum R above Dam	10	36.9%	14.1%	23.4%	43.8%
Yakima Prosser Dam to Satus	12	47.1%	7.7%	17.6%	28.9%
Yakima Ahtanum to Naches	13	16.2%	22.8%	5.6%	31.9%
Ahtanum Upper WIP to forks	15	6.0%	25.6%	1.9%	29.7%

Sorted by the combined rank; geographic areas shown below represent 75% of the restoration potential with respect to abundance.

Figure B.5: Major reach-level limiting factors for the Upper Yakima population



1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

B.2.5 Integration of Restoration Priorities Across Populations

Table B.2, Table B.3, Table B.4, and Table B.5 have presented the geographic areas with the greatest potential for restoring the components of performance for the defined populations. The geographic areas listed for each population also represent 75% of the restoration potential in terms of restoring the population's abundance to near historic levels. When viewing these Geographic areas by population with the strategic summaries (Figure B.2, Figure B.3, Figure B.4, and Figure B.5), together they illustrate the "where" and "what" components of restoration specific to individual populations. However, if we want to take a coarsened scale view of the overall benefits for multiple species in terms of restoration, we must integrate overlapping geographic areas across species and populations. This allows identifying the geographic areas that provide the "biggest bang for your buck." Geographic areas totaling 75% of the abundance restoration potential were considered priority areas for each population and were counted across populations of modeled species where overlap occurred. Results from this exercise are presented in. The model indicates restoration actions in the top 13 geographic areas would benefit nearly all anadromous species currently modeled in the basin. Further more, restoration actions within the top six geographic areas listed would improve performance of multiple populations and species. A word of caution, geographic areas in the table below represent areas of significance for a population that also overlap across multiple species and populations, there are other geographic areas not included in Table B.6 with significant restoration potential for individual species or populations.

Table B.6: Summation of individual geographic areas across steelhead populations

Numbers under the species indicate the number of populations benefiting from restoration actions in the listed geographic area. Where only one steelhead population is shown as benefiting, geographic areas are ranked in descending order according to the additional number of populations of other species shown as benefiting in Appendix M of the Yakima Subbasin Plan.

No.	Geographic Area	Steelhead
1	Yakima Prosser Dam to Satus Cr	4
2	Naches Cowiche Cr to Tieton R	1
3	Naches Tieton R to Rattlesnake Cr	1
4	Yakima Ahtanum Cr to Naches R	1
5	Naches Nile Cr to Little Naches/Bumping Confl.	1
6	Teanaway R below forks	1
7	Yakima Naches R to Roza Dam	1
8	Yakima Manastash Cr to Taneum Cr	1
9	Yakima Wilson Cr to Manastash Cr	1
10	Tieton drainage above Tieton Dam	1
11	Tieton R below Tieton Dam	1
12	Naches mouth to Cowiche Cr	1
13	Cle Elum drainage above Cle Elum Dam	1
14	Teanaway drainage above forks	1
15	Little Naches R mouth to Salmon Falls	1
16	Wilson Drainage	1
17	Cowiche Drainage	1
18	Rattlesnake Drainage	1

B.3 Preservation Potential for Individual Populations

Table B.7, Table B.8, Table B.9, and Table B.10 present the geographical areas where degradation of current habitat conditions of individual populations would have the most negative affects on modeled population characteristics. These areas should be priorities areas for efforts to protect existing habitat conditions. Geographic areas listed comprise 75% of the preservation potential with respect to abundance. The percentages should be interpreted as potential decreases in current performance of the designated population if the physical and biological environment was severely degraded. Thus, areas with high percentages should be considered priority areas for preservation. Also, the combined rank next to a geographic area considers losses endured by all performance parameters and is computed by the sum of individual ranks for each parameter.

B.3.1 Naches Steelhead

Table B.7 summarizes the high priority geographic areas for preservation potential as it applies to the Naches steelhead population. The table also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. Due to the quality of spawning/rearing habitat in the Little Naches above Salmon Falls and the Rattlesnake drainage, the model indicates these as the primary Geographic areas for preservation.

Table B.7: Geographic preservation priorities for the Naches population

Geographic areas are sorted by the combined preservation rank of performance parameters.

Naches Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area:					
L. Naches above Salmon Falls	1	-36.7%	-29.9%	-9.1%	-74.8%
Rattlesnake Drainage	1	-28.8%	-33.0%	-9.4%	-85.2%
Naches Nile to L Naches/Bumping	2	-30.0%	-20.5%	-8.5%	-48.6%
Naches Cowiche to Tieton	3	-25.1%	-13.0%	-14.0%	-35.8%
L. Naches mouth to Salmon Falls	4	-17.8%	-14.0%	-6.7%	-32.5%

B.3.2 Satus Steelhead

Table B.8 summarizes the high priority geographic areas for preservation potential as it applies to the Satus Creek steelhead population. Table B.8 also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. The model indicates degradation within the physical and biological environment of the Satus Drainage above Dry Creek would result in the loss of 80% life history pathways and 100% abundance. This is a rather large

geographic area with a high proportion of Satus Creek steelhead spawning within, explaining the consequences of degradation of this reach.

Table B.8: Geographic preservation priorities for the Satus Creek population

Geographic areas are sorted by the combined preservation rank of performance parameters.

Satus Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area:					
Satus drainage above Dry Cr	1	-80.0%	-77.2%	-45.5%	-100.0%
Dry Cr Drainage	2	-14.7%	-20.4%	-17.2%	-31.5%
Satus mouth to Dry (plus Mule-Dry)	3	-29.0%	-14.7%	-18.8%	-28.3%

B.3.3 Toppenish Steelhead

Table B.9 summarizes the high priority geographic areas for preservation potential as it applies to the Toppenish steelhead population. The table also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. The model indicates degradation within the physical and biological environment of Toppenish Creek above Lateral Canal would result in the loss of 88.6% life history pathways and 100% abundance. This is a rather large geographic area with a high proportion of Toppenish Creek steelhead spawning within, explaining the consequences of degradation of this reach.

Table B.9: Geographic preservation priorities for the Toppenish population

Geographic areas are sorted by the combined preservation rank of performance parameters.

Toppenish Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area:					
Toppenish above Lateral Canal	1	-88.6%	-96.2%	-47.9%	-100.0%
Simcoe drainage above Agency	2	-5.8%	-0.7%	-10.2%	-10.7%

B.3.4 Upper Yakima Steelhead

Table B.10 summarizes the high priority geographic areas for preservation potential as it applies to the Upper Yakima steelhead population. The table also shows the hypothesized potential losses in the performance parameters expressed as percentages decrease in the current performance of the population. The top three preservation geographic areas incorporate the Yakima mainstem upstream of the Teanaway River to Easton Dam and the Cle Elum River downstream of the dam to the confluence to the Yakima River. These

three geographic areas rank high because of their vast size, the quality of habitat relative to other geographic areas and the extended period time steelhead reside in these three geographic areas (i.e., spawning through smoltification).

Table B.10: Geographic preservation priorities for the Upper Yakima population

Geographic areas are sorted by the combined preservation rank of performance parameters.

Upper Yakima Steelhead	Combined Rank	Diversity Index	Productivity	Capacity	Abundance
Geographic Area:					
Cle Elum R below Cle Elum Dam	1	-18.6%	-27.5%	-0.2%	-51.0%
Yakima Teanaway to Cle Elum	1	-32.1%	-23.5%	-2.6%	-42.9%
Yakima Cle Elum to Easton Dam	2	-35.1%	-22.9%	-3.5%	-42.0%
Yakima Taneum to Teanaway	3	-27.0%	-15.4%	-2.0%	-25.9%
Yakima Easton to Keechelus dams	4	-15.0%	-12.8%	-1.5%	-21.0%
Yakima Manastash to Taneum	5	-12.9%	-9.8%	-8.3%	-21.8%
Yakima Wilson to Manastash	6	-11.1%	-11.0%	-4.1%	-20.1%
Yakima Roza Dam to Wilson Cr	7	-5.4%	-5.0%	-5.6%	-12.2%
Teanaway drainage above forks	8	-3.0%	-4.5%	-9.1%	-14.8%

B.4 Use of EDT to Model Restoration Scenarios

Currently the best data available for making a quantitative assessment of the response of Yakima Basin steelhead populations to restoration activities comes from two restoration scenarios developed using the EDT model. The first was developed for the Yakima Subbasin Plan in 2004-5. The second is a more intensive restoration scenario developed by modeling restoring habitat to a level that provides 50% of Proper Functioning Condition in the EDT model.[44] The Yakima Basin Fish & Wildlife Recovery Board is working with NOAA Fisheries to integrate the results of these restoration scenario into an All-H Analyzer model that assess population responses to recovery actions in the mainstem Columbia, its estuary, and the Pacific Ocean. This work is detailed in Chapter 8 of the Middle Columbia River Steelhead Recovery Plan currently being developed by

[44] The 50% of PFC model for steelhead has been developed by the Columbia Basin Fish & Wildlife Authority and will be published as part of their 2008 proposals for amendments to the NPCC Fish and Wildlife Program.

NOAA Fisheries. The Board is also investigating the possibility of conducting additional analysis using update EDT data and more detailed modeling of specific recovery actions.

For the restoration scenario developed for the Yakima Subbasin Plan, the Aquatic Technical Committee developed a restoration scenario that characterized how habitat variables would respond to fish habitat restoration efforts, and then used the EDT model to estimate how anadromous fish populations would respond. For those attributes that could be characterized in the EDT model, and were considered major limiting factors to productivity, the technical committee estimated how much they thought a given attribute could be improved over the next 30 years (roughly the time for riparian vegetation to mature if planted) given the current conditions in the subbasin, and an unlimited budget, and using existing protection or restoration techniques such as riparian zone planting, purchase of water rights, levee relocation, etc. For example, in the Upper Yakima it was not thought likely that a massive relocation of Interstate 90 was going to occur, so confinement (a major limiting factor in the upper Yakima) was rated to remain nearly the same, while in the Union Gap reach, it could conceivably improve by over 40% without relocating the freeway or the Cities of Yakima or Union Gap. In a few cases, such as reaches located in Urban Growth Areas or other rapidly developing areas with still good habitat, some slight decreases in habitat quality were also entered into the model. Specific assumptions made in developing the restoration scenario include:

1) Anadromous fish passage is made available at Bumping and Cle Elum dams, but not Tieton, Keechelus or Kachess dams;

2) Full passage is restored at all other existing passage barriers;

3) Based on the Aquatic Technical Committee's assessment of what was likely to be feasible, the model run reflects only a 10 to 15% improvement in flow conditions in the lower Naches (i.e., below the confluence with the Tieton) and lower Yakima (below Wapato Dam), which would still leave them at only an estimated 20 to 30% of unregulated averages.

4) Improvements did not cascade. In the real world, improvements in one attribute could be expected to have secondary effects on other attributes, or "cascade" through the ecosystem. Within the model, changes were made to the selected attributes only, and other attributes were held constant for the model run. This means that the Restoration reference condition is very conservative in regards to estimated productivity, abundance and diversity.

5) The model was based on existing defined populations; new spawning reaches in newly opened habitat, or entirely new populations were not defined for the restoration scenario.

The process of developing the restoration scenario and the specific adjustments to habitat parameters are described in detail in Appendix O of the Yakima Subbasin Plan (2005). In early 2008, the Subbasin plan scenario was adjusted to ensure that baseline and restored out of basin conditions were constant (this required lowering the ocean survival rates in the restoration scenario so that they matched those in the baseline scenario). Anticipated improvements in Columbia River habitat, hatchery and harvest conditions and variability

in ocean conditions will be captured in the AHA modeling process currently being conducted by NOAA Fisheries. A second adjustment was made to redraw population area boundaries to match those used in this plan; this primarily affected the Naches population, which incorporates tributary and mainstem areas that were modeled separately in 2005. The 2005 EDT-based estimates of resulting population parameters are shown in Table B.11; Table B.12 shows the 2008 adjusted version. Compared to other modeled salmon species, steelhead respond well to restoration. All existing populations are modeled to improve substantially, and population levels are well above minimum thresholds for viability. The current abundance estimates in Table B.11 differs slightly from the current levels in Table B.1 due to the use of slightly different population delineations; both tables will be updated based on a new model run based on the ICTRT population delineations that is under development. The updated model run results will be incorporated into this document once available, but significant change in the modeled response of steelhead populations to the restoration scenario is not expected.

Table B.11: EDT Subbasin restoration summary as developed in 2005

Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Satus Steelhead	Current without harvest	37%	2.4	1,516	894
	Current with harvest	37%	2.4	1,516	894
	Restored Conditions	49%	5.2	3,379	2,733
Toppenish Steelhead	Current without harvest	13%	2.5	866	513
	Current with harvest	13%	2.5	866	513
	Restored Conditions	37%	4.9	2,238	1,784
Naches Steelhead	Current without harvest	11%	1.6	2,348	920
	Current with harvest	11%	1.6	2,348	920
	Reference Conditions	60%	2.9	7,563	4,911
Upper Yakima Steelhead	Current without harvest	6%	1.9	3,177	1,479
	Current with harvest	6%	1.9	3,177	1,479
	Restored Conditions	33%	2.9	9,931	6,553

Table B.12: EDT 2005 Subbasin restoration summary as adjusted in 2008

Population	Scenario	Diversity index	Productivity	Capacity	Abundance
Satus Steelhead	Current without harvest	37%	2.4	1,472	861
	Current with harvest	37%	2.4	1,472	861
	Restored Conditions	44%	2.6	1,551	961
Toppenish Steelhead	Current without harvest	12%	2.4	860	505
	Current with harvest	12%	2.4	860	505
	Restored Conditions	20%	2.6	978	609
Naches Steelhead	Current without harvest	27%	2.6	3,192	1,977
	Current with harvest	27%	2.6	3,192	1,977
	Reference Conditions	33%	3.0	3,710	2,472
Upper Yakima Steelhead	Current without harvest	15%	2.6	1,809	1,114
	Current with harvest	15%	2.6	1,809	1,114
	Restored Conditions	27%	2.6	3,131	1,947

APPENDIX C: RECOVERY PROGRAMS OVERVIEW

C.1 Introduction

Fisheries restoration efforts in the Yakima Basin have a long history. Numerous federal, state and local programs have been established over the last 25 years. As noted in Chapter 6, this plan emphasizes implementing recovery actions through established programs and partnerships wherever possible. This appendix gives a brief overview of some of the most relevant programs. For more information, see the Yakima Subbasin Plan.

C.2 NPCC/BPA Programs

The federal Northwest Power Act of 1982 created the Northwest Power and Conservation Council and tasked it with overseeing a fish and wildlife program that is funded by BPA and mitigates for the effects of the Federal Columbia River Power System. The Council/BPA program has been the primary source of funding for fish restoration efforts in the Yakima Basin over the last 25 years, and is likely to continue to be so into the future. Table C.1 lists projects in the Yakima Basin that are currently funded by BPA.

Table C.1: BPA-funded programs in the Yakima Basin

Project #	Project Title	Sponsor	Current FY07 to 09
198812025	YKFP Management, Data, Habitat	Yakama Nation	$454,000*
199200900	Yakima Phase II/Huntsville Screen Operation & Maintenance	WDFW	$484,500
199206200	Yakama Nation - Riparian/Wetlands Restoration	Yakama Nation	$2,275,000
199405900	Yakima Basin Environmental Education Program	Eco-Northwest	$100,000*
199503300	O&M Yakima Basin Fish Screens	BOR	$273,600
199506325	Yakima Klickitat Fisheries Project - Monitoring And Evaluation	Yakama Nation & WDFW	$12,300,753
199506425	YKFP Policy/Plan/Technical	WDFW	$540,000
199603501	Yakama Reservation Watersheds Project	Yakama Nation	$1,016,457*
199701325	Yakima/Klickitat Fisheries Project Operations and Maintenance	Yakama Nation	$7,999,998
199705100	Yakima Basin Side Channels	Yakama Nation	$1,500,000
200201400	Sunnyside Wildlife Mitigation	WDFW	$634,255
200202501	Yakima Tributary Access & Habitat Program	South Central Washington RC&D	$365,178
Capital	*Yakima Tributary Access & Habitat Program*	South Central Washington RC&D	*$2165178*
Capital	*Manastash Creek Passage & Screening*	*Kittitas County Conservation District*	*$2327432*
200600400	Wenas Wildlife Area O&M	WDFW	$868,720
200702000	Manastash Instream Flow Enhancement	Kittitas County Conservation	$892,998
200711200	Teanaway Watershed Protection & Enhancement	Kittitas Conservation Trust	$1,020,000
200711300	Cowiche Restoration and Protection Project	WDFW	$300,000
200719400	Oak Flats Acquisition and Habitat Enhancement	WDFW	$550,000
		Totals	***36,068,069***

***FY 2007 funding commitment only**

BPA is currently making commitments to additional funding for tributary habitat improvements as part of negotiating an ESA Biological Opinion for the Columbia River Power system, and it is likely that at least some of this funding will be used in the Yakima Basin to improve steelhead habitat.

Selected BPA-funded projects with strong ties to steelhead recovery are described below.

C.2.1 The Yakima/Klickitat Fisheries Project

The Yakima Klickitat Fisheries Project (YKFP) is a joint project of the Yakama Nation Fisheries Program and WDFW that is funded via four separate contracts with BPA. It is the largest fish management program in the basin. Its goals are to:

- Enhance existing stocks of anadromous fish in the Yakima and Klickitat river basins while maintaining genetic resources and minimizing negative ecological interactions with wild populations.
- Reintroduce stocks formerly present in the basins.
- Apply knowledge gained about hatchery supplementation throughout the Columbia River Basin.

The YKFP program runs supplementation hatchery programs for spring and fall Chinook and coho salmon. Opportunities to reintroduce extirpated summer Chinook and sockeye runs are being evaluated. The YKFP program also undertakes extensive research and monitoring to understand factors affecting target populations, and to evaluate the effects of supplementation activities on other components of the ecosystem. The program maintains 15 different fish production and research facilities in the basin and employees approximately eighty people, including managers, scientists, technicians, fish culturists, laborers and office support personnel. It also supports efforts to improve, restore, and protect fish habitat in the basin, and to influence policies related to fish management in the Yakima Basin. The YKFP program is the primary source and steward of fish related data in the basin, and maintains the EDT model used to evaluate the historic, current and potential future conditions of fish habitat within the Yakima Subbasin.

YKFP activities focused on steelhead include the kelt reconditioning program at the Prosser hatchery, research into the genetics of Yakima Basin steelhead, and monitoring of steelhead adults, juveniles and smolts. The fish counting facilities at Roza and Prosser dams are operated by YKFP. The YKFP program is currently developing a steelhead master plan; this process will be coordinated with ongoing recovery planning and implementation, and will identify possible supplementation actions.

C.2.2 Yakima Tributary Access and Habitat Program

The listing of Middle Columbia River Steelhead focused the attention of both landowners and regulatory agencies on the numerous unscreened irrigation diversions and passage barriers in Yakima and Kittitas counties. In response, local organizations, including the South Central RC & D, the Kittitas County and North Yakima Conservation Districts, WDFW, the Yakima Nation and others, partnered to apply for BPA funding for the Yakima Tributary Access & Habitat Program (YTAHP). This program has funded assessments of tributary passage, screening and habitat conditions, and subsequent on-the-ground projects to screen irrigation diversions, remove fish passage barriers and improve riparian habitat conditions. From 2002 to 2008, YTAHP and its partners screened 87 cfs of irrigation water, removed 21 passage barriers to access over 45 miles

of habitat, trusted 4.5 cfs of water to instream use, planted 4.95 miles of stream bank, and used YTHAP funded staff and resources to leverage over $7.6 million in total project funding.

C.2.3 Yakima Side Channels Program

This project has funded acquisition and restoration of side channel and floodplain habitats in alluvial reaches of the Yakima and Naches rivers.

C.2.4 Yakama Reservation Watersheds Project

This project focuses on restoration of anadromous fish bearing streams on the Yakima Reservation. It has funded habitat protection and enhancement in Satus Creek, flow improvements, obstruction removal, and screening in Toppenish Creek, and flow restoration and riparian/floodplain protection on Ahtanum Creek. Redd surveys, smolt trapping and other monitoring are conducted in all three areas. This project has been the main source of funding for restoration actions for the Satus and Toppenish steelhead populations.

C.2.5 Manastash Creek Passage/Screening/Flow Projects

These two projects focus on removing passage barriers and improving instream flows in the lower section of Manastash Creek, which has been inaccessible to steelhead for more than a century. Restoring access to Manastash Creek is a high priority action for the Upper Yakima steelhead population.

C.2.6 Teanaway Watershed Protection and Enhancement

This project focuses on protecting and restoring the floodplains and riparian areas of the Teanaway River, which is one of the main areas currently used by steelhead in the Upper Yakima population area.

C.3 U.S. Bureau of Reclamation Programs

C.3.1 System Operations

The Yakima Field Office (YFO) Manager, in consultation with numerous entities, determines how the BOR's Yakima Project storage reservoirs and diversions are operated. In 1980, the Quackenbush decision required Reclamation to incorporate fish concerns into its management of the Yakima Project. The System Operations Advisory Committee (SOAC) was formed by the Yakima Field Office Manager in response to the supplemental instructions entitled 'Supplementary Instructions to the Water Master' November 28, 1980, in the case of Kittitas Reclamation District, et al. vs. the Sunnyside Valley Irrigation District, et al. SOAC is comprised of fish biologists representing the USFWS, the Yakama Nation, WDFW, and water users represented by the Yakima Basin Joint Board. SOAC and others provide input to the YFO Manager on operations of the Yakima Project for fish and wildlife purposes. The group worked with Reclamation to

develop the flip-flop concept. Phase 2 of the Yakima enhancement legislation (see below) in 1994 directed SOAC to develop a report on biologically based flow needs for fish in the basin. The completed report lists recommendations for studies, models, etc. that may in turn result in biological flow recommendations.

C.3.2 Yakima River Basin Water Enhancement Project

Public Law 103-434, Title XII, Yakima River Basin Water Enhancement Project (YRBWEP) was authorized by Congress in 1994. It is a multi-faceted program intended to promote water conservation, improve the reliability of the water supply for irrigation and protect, mitigate and enhance the fish and wildlife resources of the Yakima River Basin. The legislation authorizes Reclamation to work with partners to plan and implement water conservation measures throughout the Yakima River Basin, and to acquire land and water from willing sellers or lessors to improve instream flow conditions. For conservation projects, two-thirds of the conserved water is dedicated to improving instream flows. Key partners include the WDOE, the Yakama Nation, BPA, Natural Resources Conservation Service and irrigation districts. The Conservation Advisory Group (CAG) provides recommendations to the YFO Manager regarding the structure and implementation of the Basin Conservation Program. Funding for YRBWEP is dependant on Congressional appropriations. Examples of projects completed via YRBWEP include:

1) Purchase of the Wapatox Power Plant, which allows 260,000 acre-feet of water previous diverted out of the lower Naches River for power production to be left instream in an 8-mile long stretch of critical habitat

2) Work with irrigators, BPA and the Yakama Nation to increase instream flows in the Teanaway River by designing and installing two pumping plants and pipelines that increase irrigation efficiencies and divert water three miles below the original diversions

3) Sunnyside Valley Irrigation District’s construction of three reregulation reservoirs and numerous check structures. Close to 100 cfs of conserved water will be used to enhance instream flows in the Wapato reach, the most severely dewatered mainstem reach in the subbasin

4) Purchase of floodplain habitat on Taneum Creek and the Yakima River near Ellensburg

5) Purchase of lands in the Gap-to-Gap reach in the Yakima area. Approximately 600 acres of land purchased are now in various stages of being converted from agricultural or grazing lands to native grass stands

Current YRBWEP priorities include:

1) Continued cooperative work with numerous entities to set back levees and restore natural floodplain habitat and function in the Gap to Gap reach and other key sites

2) Efforts with the Yakama Nation and the Bureau of Indian Affairs to improve the efficiency of the Wapato Irrigation Project and restore the Toppenish Creek floodplain

3) Proposal to move the point of diversion for the Benton Irrigation District downstream. This would result in an additional 58 cfs remaining in the river for a 72 mile reach

4) Proposal to add a diversion at Kiona for the Kennewick Irrigation District. This would reduce the amount of water diverted at Chandler and leave additional water in the reach from Chandler to Kiona

5) Phase II irrigation efficiency improvements by the Sunnyside Irrigation District, such as piping laterals

6) Future conservation projects with other irrigation districts such as Naches-Selah and Roza, and others

C.3.3 Yakima River Basin Water Storage Options Feasibility Study

The BOR and the state Department of Ecology are conducting a joint study of the feasibility of augmenting water supplies in the Yakima River Basin through construction of additional storage reservoirs, including the possibility of using of Columbia River water in the Yakima Basin. The goals of the proposals reviewed in the study are to: 1) improve flow conditions for anadromous fish, 2) provide a more reliable water supply for existing irrigators, and 3) provide additional water supply for future municipal demands. The study will be completed in 2008, and will detail the feasibility and costs and benefits of the:

1) Black Rock Reservoir proposal, which involves pumping water from the Columbia River into the proposed Black Rock Reservoir for subsequent use on the Roza and Sunnyside Irrigation Districts

2) Wymer Reservoir proposal, which involves a smaller reservoir which would be filled by pumping from the Yakima River during higher flow periods and by the winter release of Cle Elum Reservoir irrigation water.

3) Wymer proposal, as above, plus a pipeline that would pump water from the Columbia River to the Roza and Sunnyside Irrigation Districts.

Models and analyses developed as part of the storage study will increase our understanding of the relationship between flows, habitat characteristics such as sediment transport, water temperature and floodplain complexity, and fish production. These products will inform several key recovery actions identified in this plan.

The WDOE is conducting a parallel study of non-storage alternatives for increasing water availability, including: 1) enhanced water conservation, 2) market-based reallocation of water resources, and 3) groundwater storage.

C.3.4 Storage Dam Fish Passage Feasibility Study

The BOR is working with the Yakama Nation, WDFW, USFWS, NOAA Fisheries and others to determine the feasibility of providing fish passage at the five Yakima Project storage dams (Tieton, Bumping, Kachess, Keechelus, and Cle Elum dams). Four of the five reservoirs were originally natural lakes and historically supported sockeye salmon and other anadromous and resident fish. When the dams were built to enlarge (or in the case of Tieton Dam, create) the lakes in the early 20th century, no fish passage facilities were provided. Providing fish passage at these dams has the potential to increase the distribution and abundance of steelhead, coho salmon, and Chinook salmon, allow for reintroduce of sockeye salmon to the basin, and reconnect isolated populations of bull trout. Reclamation began detailed studies to evaluate the feasibility of providing passage at the dams in 2004. Current feasibility-grade investigations are focusing on the engineering, operational, and biological parameters needed to provide fish passage at Cle Elum and Bumping Lake dams. Evaluation of passage opportunities at the other three dams will follow. The feasibility report on Cle Elum and Bumping Lake dams is scheduled for completion in 2008.

C.4 US Forest Service Restoration Programs

The Cle Elum and Naches Ranger Districts of the Wenatchee National Forest encompass significant portions of the Upper Yakima and Naches population areas. Since 2002, both Districts have implemented the Respect the River education and restoration program, with each District expending at least $10-50,000 per year on education and on-the-ground restoration of recreation-impacted stream reaches. Cost-share partners in these projects include RCO, USFWS, Plum Creek, RIDGE, Mid-Columbia Fisheries Enhancement Group, Conservation Northwest, and the Forest Service’s Challenge Cost Share Program and Rural Development Act Title II funds. The USFS has also been actively removing known fish-passage barriers, improving riparian grazing management on Forest Service allotments, and reducing risk of landscape-scale fire.

C.5 Washington State Fish Recovery Programs

C.5.1 Regional Fisheries Enhancement Groups

Mid-Columbia Fisheries Enhancement Group is one of 14 Regional Fisheries Enhancement Groups (RFEGs) in Washington State. The RFEG program was created by the state legislature in 1990 to involve local communities, citizen volunteers, and landowners in the salmon enhancement. Since that time, the groups have become important partners in the state's salmon recovery efforts. The groups receive base funding from a surcharge on sport and commercial fishing license fees, through an account administered by the Washington Department of Fish & Wildlife.

The Mid-Columbia Fisheries Enhancement Group’s region covers south central Washington and includes all of the Yakima Basin. MCFEG is a non-profit organization dedicated restoring self-sustaining salmonid populations through habitat preservation,

restoration and education projects, which assist landowners and promote community partnerships. A volunteer board of directors runs the group. Mid-Columbia Fisheries Enhancement Group supplements their base funding with grants, volunteer efforts, and community donations to promote, support, and sponsor fish habitat restoration and enhancement projects and watershed education programs.

C.5.2 Salmon Recovery Funding Board Programs

After the listing of Columbia River and Puget Sound stocks under the Endangered Species Act, the governor and legislature of Washington State passed the Salmon Recovery Act of 1998. This created the statewide Salmon Recovery Funding Board (SRFB) and tasked it with funding habitat improvement projects with state appropriations and Washington's portion of the federal Pacific Coastal Salmon Recovery Fund administered by NOAA Fisheries. Washington's Recreation and Conservation Office administers the SRFB and its funding programs. The Salmon Recovery Act also called for creation of Lead Entities, which are local organizations that work at a watershed scale to prioritize and propose projects for SRFB funding. Lead Entities operate with technical and financial support from WDFW. The Yakima Basin Fish & Wildlife Recovery Board is under contract with WDFW to act as the Lead Entity for the Yakima Basin. From 1999 to 2006, the Yakima River Basin Salmon Recovery Board, which was administered by the city of Selah, served as the Lead Entity.

Each year, the Lead Entity solicits SRFB proposals from potential project sponsors in the basin, convenes technical and citizen's committees to review and prioritize the proposals, and submits a list of recommended projects to the SRFB. Priorities are guided by the Yakima Watershed Salmon Recovery Strategy, and, since 2006, the Yakima Subbasin Salmon Recovery Plan. Between 1999 and 2007, the SRFB has provided a total of $8.5 million for 44 fish habitat projects in the Yakima Basin. These include acquisitions of key fish habitat, projects to improve fish passage at road crossings and irrigation diversions, and projects that improve riparian and floodplain function. More information is available on the Board's webpage.

C.5.3 Regional Salmon Recovery Organizations

As part of Washington's Strategy for Salmon Recovery, the State has encouraged the formation of local boards that are recognized by the state as "regional salmon recovery organizations." The state has contracted with these boards to develop regional salmon recovery plans that form the basin for federal Endangered Species Act recovery plans for salmonids in Washington. The state has provided technical and logistical support via the Governor's Salmon Recovery Office. The Yakima Subbasin Fish and Wildlife Planning Board (YSPB) was created in 2002, in response to requests from the Northwest Power and Conservation Council and the Washington Governor's Salmon Recovery Office. It drafted the Yakima Subbasin Plan under contract with BPA, and developed the initial 2005 draft of this plan with funding from the State of Washington, as described in Chapter 1. In April 2006, this Board and the Yakima Lead Entity were merged to form the Yakima Basin Fish & Wildlife Recovery Board, which was recognized as the regional salmon recovery organization for the Yakima Basin and took on responsibility for

completion of the Yakima Subbasin Salmon Recovery Plan. It is under contract with the state to complete the plan and coordinate its implementation in the Yakima Basin, as described in Chapter 6.

C.5.4 Ahtanum Creek Watershed Restoration Program

The Washington State Department of Ecology is facilitating development of a watershed restoration program for the Ahtanum Creek watershed. The objectives of the program are to:

- Develop water management strategies to improve water availability for agricultural and other out-of-stream uses in the Ahtanum Creek Watershed and provide a net benefit to the watershed aquatic ecosystem (such as fish, wildlife, plants, and habitat).
- Develop land use protection and restoration strategies to preserve and enhance Ahtanum Creek floodplain and habitat value, as well as the stability and longevity of the agricultural land uses and economy within the Ahtanum Creek Watershed.

A major action that is being considered in the Restoration Program is the Pine Hollow Reservoir, which would improve both irrigation water supplies and instream flows. The program is also developing a comprehensive list of fish habitat enhancement activities for the watershed. The program is described in detail in it Environmental Impact Statement (EIS).

C.6 Washington Department of Ecology Water Quality Programs

In accordance with Section 303(d) of the Clean Water Act, every two years the state must identify its polluted water bodies and the type of pollution contaminating them and submit this list to EPA. In 2000, the state listed over 50 sections of streams and rivers in the Yakima Subbasin as impaired. The WDOE has initiated or completed Total Maximum Daily Load (TMDL) plans for the Granger Drain (sediment), the Teanaway River (temperature), the Lower Yakima River (sediment), the Upper Yakima River (sediment), Wilson Creek (sediment), and Naches (temperature). With cooperation from irrigation districts, agricultural organizations, other state and federal agencies and local governments, implementation of these TMDL plans has resulted in dramatic decreases in pollutant loading in both the upper and lower Yakima River. WDOE also funds water quality projects through its 319 and Centennial Water Quality grants program.

C.8 Yakima Basin Joint Board

The Yakima Basin Joint Board of Control is a group of irrigation districts that works together to address common technical, legal, and policy issues. They are represented on SOAC by a fish biologist. The majority of projects the Joint Board funds are research or monitoring oriented. Past work includes assessments of fish use and habitat conditions within irrigation-district managed facilities, development of a water temperature model for the lower Yakima, and analysis of the population status of species that may be affected by management actions. Most major projects that improve water quality and

irrigation efficiencies are undertaken by each individual irrigation entity, groups of irrigators, or through YRBWEP. The Roza-Sunnyside Board of Joint Control is a separate organization that administers the water quality program in the lower valley in association with South Yakima Conservation District; the Kittitas County Water Purveyors coordinates water quality and irrigation system improvements in the Upper Yakima.

C.9 Local Government Land Use Regulations

C.9.1 Growth Management Act

The Growth Management Act (GMA) (RCW 36.70A) was passed in 1990. Several of its provisions pertain to fish habitat:

- A Comprehensive Plan is the official land use policy for a local government
- Regulatory ordinances to implement the plan are required, and must and be consistent with the plan policy
- For public health and safety, the protection of ground and surface waters from pollution is require.
- Local governments must first identify (i.e., map) and then protect with regulations "natural resource lands" (agricultural and mineral resources lands), and "Critical Resources Areas," of which there are five (frequently flooded areas, geologically hazardous areas, wetlands, critical aquifer recharge areas, and fish and wildlife habitat conservation areas)
- Regulations protecting Critical Resources must be based upon "best available science"

Not all counties and cities within the state are required to prepare and implement comprehensive plans under GMA. But all counties and cities, whether planning under GMA or not, are required to identify Critical Resource Areas and protect them by regulation. Critical Resource Area Ordinances are applied only through a development review process initiated by a submitted application to undertake a regulated action, or through an enforcement/compliance action related to a project action that has not been reviewed and authorized (permitted) by the local jurisdiction.

C.9.2 Shoreline Management Act

The state Shoreline Management Act (SMA) requires cities and counties with lands on "state waters" to adopt a Shorelines Management Plan and implementing regulations. Typical plans prepared prior to the most recent edition of the State Shorelines Guidelines included three or four general land use designations (e.g., Rural, Urban, Industrial), and an implementing ordinance intended to regulate development consistent with the protection of shoreline resources and public access to the shoreline. Local SMA permit actions can be appealed to the State Shorelines Board, which can deny or modify a local permit action. Under the state rules, certain categories of development are exempt from

shorelines review. The boundary of SMA jurisdiction is generally extends 200’ upland of the ordinary high water line but can extend further upland to include the 100 year floodplain and riverine wetlands. Public notice for shoreline actions is required.

APPENDIX D: Stakeholder and Public Meetings

During the initial development of this plan, and extensive series of meeting was held to gather public input (see Section 1.3.2 and D.1 below). The October 2005 draft of the Yakima Subbasin Salmon Recovery Plan was made available via the Yakima Basin Fish & Wildlife Recovery Board's website and was put out for formal public review by NOAA Fisheries in the spring 2006 (See Section 1.1.3). Formal comments were received from American Rivers, the Yakima Basin Joint Board of Control, and the BOR. Meetings held following the Board's assumption of responsibility for the plan are listed in Section D.2. This final review draft will be made available via the Board's website and at public locations throughout the Basin. Additional meetings held after release of this review draft will be listed in section D.3 in the final version of this plan.

D.1 Stakeholder Meetings Held in 2005

The Yakima Subbasin Fish & Wildlife Planning Board and partners met with the following organizations during development of the initial draft of the Yakima Subbasin Salmon Recovery Plan in 2005:

Naches Ranger District, Wenatchee National Forest, USFS	*February 23, 2005*
Bureau of Reclamation, Yakima	*February 28, 2005*
Cle-Elum Ranger District, Wenatchee National Forest, USFS	*March 8, 2005*
North Yakima Conservation District	*March 9, 2005*
Washington State Department of Fish and Wildlife	*March 16, 2005*
Kittitas County Conservation District	*March 18, 2005*
Kittitas County Water Purveyors	*March 18, 2005*
City of Yakima Water Systems	*March 23, 2005*
City of Yakima Maintenance	*March 23, 2005*
City of Yakima Planning	*March 23, 2005*
Washington Department of Ecology	*March 25, 2005*
Yakima Basin Joint Board Of Control	*March 25, 2005*
Kittitas Irrigation District	*March 25, 2005*
Roza Irrigation District	*March 25, 2005*
Sunnyside Irrigation District	*March 25, 2005*
Richland Irrigation District	*March 25, 2005*
Cascade Irrigation District	*March 25, 2005*
Benton County Conservation District	*March 28, 2005*

South Yakima Conservation District	*March 28, 2005*
Barker Ranch	*March 28, 2005*
Yakima County Public Works Maintenance	*March 31, 2005*
City of Richland	*April 4, 2005*
Ahtanum Irrigation District	*April 4, 2005*
Washington Department Of Transportation	*April 4, 2005*
Yakima County Planning	*April 6, 2005*
South Central Washington Resource Conservation & Development	*April 6, 2005*
Yakima Tributary Access and Habitat Project	*April 6, 2005*
Yakima Audubon	*April 12, 2005*
Washington State Cattlemen's Association	*April 18, 2005*
City of Ellensburg Public Works Department	*April 19, 2005*
Washington Department of Natural Resources	*April 22, 2005*
Washington Farm Bureau	*April 25, 2005*

D.2 Stakeholder Meetings Held April 2006 to January 2008

Responsibility for completion of this plan transferred to the Yakima Basin Fish & Wildlife Recovery Board in April 2006. Regular updates on the planning process were held at the regular public meetings of the Yakima Basin Fish & Wildlife Recovery Board's Board of Directors. Additional stakeholder meeting that were held to update interested parties on the planning process following this transfer include:

Selah Kiwanis	*November 28, 2006*
Mid-Columbia Regional Fisheries Enhancement Group	*January 18, 2007*
Yakima Aquatic Science & Management Conference	*June 14, 2007*
South Central WA Resource, Conservation & Development	*September 6, 2007*
Yakima/Klickitat Fisheries Project Policy Group	*September 19, 2007*
Benton County Conservation District	*October 10, 2007*
Yakima Basin Joint Board of Control	*Nov. 14 & 30, 2007*
Bureau of Reclamation, Yakima	*May 22, 2008*
Washington Department of Fish & Wildlife	*May 23, 2008*

In April though June of 2008, the Board received informal comments on the March 24, 2008 review draft. A summary of comments and responses is available on the Board's website (www.ybfwrb.org); changes made to the plan in response to these comments are included in this draft.

D.3 Plan Outreach During 2008 NOAA Comment Period

During the September 23rd to December 23rd formal comment period on the NOAA Middle Columbia Steelhead Recovery Plan, the Yakima Basin Fish & Wildlife Recovery Board conducted the following outreach activities:

General Outreach:

Press release to local papers on release day (resulted in Yakima Herald Article)

Information on plan and comment period posted on Board website

Federal Register notice on Sept. 24th by NOAA

Email about comment period to Board email contacts (last week of Sept & mid-Nov)

Presentations:

Yakima Basin Joint Board (major irrigators)

Yakima Audubon

Yakima Flyfishing Club

Cowiche Canyon Conservancy

Federal Caucus (federal agencies involved in Columbia salmon issues)

Federal legislative staffers (via NOAA conference call)

Yakima Basin Water Resources Agency Board

NOAA Public meeting Nov 19th

Yakima Basin Water Resources Agency Water Resource Advisory Board (Dec 1st)

South Yakima Conservation District

Kittitas Cattle Growers

Informational materials and offer to present if requested provided to:

Conservation Districts (North Yakima, Kittitas, South Yakima & Benton)

Kittitas Field & Stream Club

Mid-Columbia Regional Fisheries Enhancement Group

State legislators (via email on release date of NOAA plan)

Tapteal Greenway Association

Benton Conservation District

Phone Discussions

Bureau of Reclamation staff

US Forest Service staff

Native Fish Society

American Rivers

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Recovery Plan Module
Mainstem Columbia River Hydropower Projects

1.0 Purpose

This module summarizes the general effects of Columbia River mainstem hydropower projects on all 13 Endangered Species Act (ESA)-listed anadromous salmonids in the Columbia basin, including the limiting factors and threats and expected actions (including site-specific management actions), or strategy options, to address those threats. The area to be addressed by the module includes the accessible mainstem habitat in the upper Columbia (i.e., to the tailrace of Chief Joseph Dam) and Snake (i.e., to the tailrace of Hells Canyon Dam) rivers, respectively, downstream to the tailrace of Bonneville Dam.[1] This module supports plans for the Snake River, Upper Columbia, Middle Columbia, Lower Columbia, and Upper Willamette River species, replacing the previous version provided as guidance to regional recovery planners, dated September 25, 2006. The material that follows is a synthesis of information that has undergone public processes for review, including, but not limited to, the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion, Federal Energy Regulatory Commission (FERC) licensing proceedings, and Habitat Conservation Plans (HCPs). This module may, however, be updated as additional information becomes available.

1.1 How Salmon and Steelhead Use the Mainstem

All 13 ESA-listed species of salmon *(Oncorhynchus spp.)* and steelhead *(O. mykiss)* in the Columbia basin use the mainstem Columbia River (and Snake River for Snake River species) for migration to and from freshwater natal areas to the Pacific Ocean, where they grow from juveniles to mature adults. Most of the ESA-listed species spawn and incubate in tributaries, but Snake River (SR) fall Chinook, some populations of Lower Columbia River (LCR) fall Chinook, and Columbia River (CR) chum salmon spawn and incubate redds in the mainstem itself. Historically, the peak period for migration to the ocean has been spring and early summer, corresponding with snowmelt in the upper basin and high seasonal flows. However, individual juveniles from one species/population or another can be found in the system throughout the year.

Downstream travel has been shown to be active rather than passive; in addition to water velocity, the rate of travel is affected by date, temperature, the location where the fish begin their migration, fish size, and the extent of the parr-smolt transformation. Survival through the migration corridor declines with distance traveled, whether due to natural hazards (including predation), mortality due to passage at hydroelectric projects, or other factors associated with

[1] A separate module (the Mainstem Columbia River Estuary Recovery Plan Module) provides the same types of information for the lower river below Bonneville, in the estuary and the ocean plume.

development (exotic predators, habitat conditions that make native predators more efficient, water quality, etc.).

Based on emigration and rearing strategies, Connor et al. (2005) described two juvenile life history types for Snake River fall Chinook. At the time of the ESA listing (June 28, 2005; NMFS 2005), it was assumed that all juveniles of this species were ocean-type fish, characterized by entering saltwater at age 0 and spending their first winter in the ocean. However, some of the smaller, later-migrating fall Chinook salmon from the Snake River basin delay seaward movement, wintering in the lower Snake River reservoirs before resuming their seaward movement the following spring at age 1. According to Connor et al. (2005), although the condition of reservoir-type juveniles decreased over winter compared with ocean-type juveniles, the mean condition factor of the former always exceeded 1.0 in the single year of study.

After growth and maturation, whether in freshwater or the ocean, adult salmonids and steelhead generally return to their natal spawning areas for reproduction, though some straying into other basins is natural. As described in ISG (1996), the timing of adult entry and movement in rivers and tributary streams, and even the size, shape, and strength of adult fish represent adaptations to the physical and biological challenges presented by the upstream route to a specific spawning area. For example, waterfalls and similar physical barriers may be passable only at the range of flows that typically occurs during one month of the year, and then only by fish that have the physical ability to jump over or otherwise ascend the barrier. For fall-spawning fish, warm water conditions in late summer often present thermal barriers to movement and there may be little suitable habitat for resting (Berman and Quinn 1991, cited in ISG 1996). Therefore, at the adult life stage, population-specific behavioral patterns, closely attuned to the available habitats, appear to be critical for survival and successful reproduction.

Preferred spawning habitat is determined by the incubation needs of embryos, i.e., high flow of oxygenated water through the interstitial spaces in the streambed (Quinn 2005). Salmon usually avoid both the slowest water (where fine sand and silt accumulate) and the fastest water. Salmon lay their eggs in nests called redds. In areas where winter freezing can destroy embryos, salmon often build redds at sites with upwelling groundwater, which is warmer than river water. In the Columbia basin, two of the listed species, Snake River fall Chinook and Columbia River chum salmon, spawn both in tributaries and in the mainstem. In the vicinity of Ives Island (downstream of Bonneville Dam), chum spawn in shallow areas where it appears that river water is warmed by its transit through the gravel (Geist et al. 2002). At both Ives Island and in the Hanford Reach, fall Chinook salmon select upwelling sites in preference to non-upwelling sites (Geist 2000; Arntzen et al. 2005), but in other locations, fall Chinook prefer to spawn in downwelling areas at the heads of riffles (Healey 1991). At both Ives Island and the Hanford Reach, fall Chinook salmon select redd sites containing the highest dissolved oxygen concentrations in the river and riverbed, which is consistent with the requirements for incubating relatively large eggs (Healy 1991).

2.0 Habitat Limiting Factors and Threats Related to Mainstem Hydropower Projects and Operations

This section identifies the past and continuing effects of dams and reservoirs located in the mainstem Columbia and Snake River migratory corridors on listed species of salmon and steelhead and their designated critical habitat. The mainstem migratory corridor extends from the base of Hells Canyon Dam on the Snake River, and from Chief Joseph Dam on the Columbia River, to the tailrace of Bonneville Dam on the Columbia River.

Columbia River Basin anadromous salmon and steelhead have been affected by the development and operation of dams. Mainstem dams have extirpated anadromous fish from their pre-development spawning and rearing habitats. Dams and reservoirs, within the currently accessible migratory corridor, have altered the river environment and have affected fish passage and survival. The operation of water storage projects has altered the natural hydrograph of the Snake and Columbia Rivers. Water impoundment and dam operations also affect downstream water quality characteristics, including water temperatures, which are important to the survival of anadromous fish. Detailed descriptions of these effects are provided in Williams et al. 2005 and Ferguson et al. 2005 (NOAA Technical Memoranda NMFS-NWFSC-63 and 64) and summarized in NMFS 2008a (Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions – Section 5.1).

2.1 Blocked and Inundated Habitat

The construction of Grand Coulee Dam in 1939 – River Mile 597 (and later Chief Joseph Dam in 1961 – RM 545) blocked access to important historical production areas for Upper Columbia River (UCR) spring Chinook salmon and steelhead (NRC 1996; ICTRT 2003) upstream of River Mile 597 (and RM 545). In addition to mainstem production areas, the Sanpoil, Spokane, Colville, Kettle, Pend Oreille, and Kootenai rivers each may have supported one or more populations of Chinook and/or steelhead.

In the Snake River, the construction of Swan Falls Dam in 1901 blocked access to important historical production areas of salmon and steelhead in the Snake River basin upstream of RM 424.[2] The construction of the Hells Canyon Dam complex (1958–1967) cut off access to the remaining historical habitat upstream of river RM 248, including seven major tributaries that had historically been important for spring/summer Chinook salmon and steelhead (and to sockeye

[2] The area downstream of RM 578 (near the present location of Upper Salmon Falls Dam) was especially important to Snake River fall Chinook salmon, which Evermann (1896) identified as the "... largest and most important salmon spawning ground of which we know in Snake River."

salmon in the Payette River system): Boise, Burnt, Malheur, Owyhee, Payette, Powder, and Weiser rivers (Fulton 1968; Fulton 1970; Gustafson et al. 1997).

Between 1938 and 1971, the construction of Bonneville, The Dalles, John Day, and McNary dams inundated mainstem habitat in the lower Columbia River between Bonneville Dam (RM 146) and the confluence of the Snake River (RM 324). Between 1933 and 1967, the construction of Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams inundated mainstem habitat in the middle Columbia River between the Snake River confluence (RM 324) and Chief Joseph Dam (545). Another 147 miles (RM 0 to RM 147) of mainstem habitat was inundated in the Snake River with the construction of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams between 1962 and 1975 (Groves and Chandler 1999). Upstream from Bonneville Dam, the 41-mile stretch of the Columbia River known as the Hanford Reach between the head of Lake Wallula (McNary Dam pool – RM 356) and the tailrace of Priest Rapids Dam (RM 397), and the approximately 101-mile stretch of the Snake River, often referred to as the Hells Canyon reach (RM 147 to 248), provide the longest remaining unregulated reach of the mainstem ecosystem between Bonneville Dam and Chief Joseph Dam on the Columbia River and Hells Canyon Dam on the Snake River.

2.2 Mainstem Habitats & the Migratory Corridor

The Columbia and Snake Rivers (mainstem habitat) serve as corridors for migrating salmon and steelhead between the Pacific Ocean and their freshwater spawning and rearing habitats. Features of migration habitat important to these fish generally include: substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food (prey), riparian vegetation, space, and safe passage. For fall Chinook salmon, and to a lesser extent chum salmon, mainstem habitat also serves as important spawning and rearing habitat. Features of spawning and rearing habitat that are important to these fish generally include: spawning gravel, water quality, water quantity, water temperature, food, riparian vegetation, and access to spawning and rearing areas.

Current conditions within much of the mainstem Columbia and Snake Rivers are altered compared to historical conditions. The development of mainstem hydropower projects have resulted in the inundation of many mainstem spawning and shallow-water rearing areas (loss of spawning gravels and access to spawning and rearing areas); altered water quality (reduced spring turbidity levels), water quantity (seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), water temperature (including generally warmer minimum winter temperatures and cooler maximum summer temperatures), water velocity (reduced spring flows and increased cross-sectional areas of the river channel), food (alteration of food webs, including the type and availability of prey species), and safe passage (increased mortality rates of migrating juveniles) (Williams et. al 2005; Ferguson et. al 2005).

Within the migratory corridor, both dams and their associated reservoirs influence the current status of Columbia Basin salmon. To a greater or lesser extent specific to each dam, the dams present fish passage hazards, causing passage delays and varying rates of injury and mortality.

2.2.1 Adult Passage

Unlike downstream migrating juveniles, there is no indication that reservoirs substantially delay adult upstream migration (Ferguson et al. 2005). While the upstream migration of adults can be slowed as fish search for fishway entrances and navigate through the fishways themselves, they migrate more quickly through the relatively slow reservoirs.

Adult fish passage, in the form of fish ladders, is provided at the eight mainstem projects in the lower Snake and lower Columbia rivers and the five mainstem FERC-licensed projects in the middle Columbia reach. In general, adult passage facilities are highly effective. Nonetheless, salmon may have difficulty finding ladder entrances, and fish also may fall back over the dam, either voluntarily (e.g., adults that "overshoot" their natal stream and migrate downstream through a dam on their own volition), or involuntarily (entrained in spillway flow after exiting a fish ladder). Some adults that fall back or migrate downstream pass through project turbines and juvenile bypass systems. Adult mortality rates have been estimated at between 22% and 59%, depending on the species and size of the individual fish (larger fish are more likely to contact a turbine blade, etc.) (Ferguson et al. 2005). There is even less data on the survival of adults through juvenile bypass systems. It seems logical to assume that survival rates would be much higher through these systems than through turbine units, and indeed, with the possible exception of passage through the 14 to 16" gatewell orifices, conditions within these systems should be easily navigable by adults.

However, in spite of these potential hazards, average survival estimates using known origin PIT-tagged fish indicate that, after adjusting for known harvest and "natural" straying, survival through the mainstem Snake and Columbia River projects is relatively high (see Table 1 and discussion in Section 4 below).

Steelhead Kelts

Unlike other Pacific salmonids, a large fraction of the adult steelhead does not die after spawning and instead attempts to migrate back to the Pacific Ocean. Termed kelts, very few post-spawn adult steelhead survive downstream passage through the hydrosystem and so do not return and spawn again. Estimates of FCRPS passage survival ranged from 4.1 to 6.0% in the low flow year 2001 to 15.6% in 2002 and 34% in 2003 (Boggs and Peery 2004; Wertheimer and Evans 2005). At present, juvenile collection and bypass systems are not designed to safely pass adult fish including kelts. In addition to injury and mortality, kelt downstream migrations are delayed by the mainstem projects (Wertheimer and Evans 2005) in a manner similar to that previously described for juveniles.

The fraction of repeat spawning kelts in steelhead populations varies widely, from 1 to 51% (Wertheimer and Evans 2005). Boggs and Peery (2004) cite an estimated 2% kelt rate for the Clearwater River in 1954. It is estimated that 17 to 25% of the steelhead that pass Lower Granite Dam return downstream as kelts (Boggs and Peery 2004; Wertheimer and Evans 2005). Thus, while there is a relatively large number of kelts present, their relatively poor survival through the FCRPS (and potentially through the Middle Columbia PUD projects) may limit the contribution that they can make to steelhead populations.

Predation

Additionally, at Bonneville Dam, marine mammals (both the more common California sea lion and ESA-listed Stellar sea lion) are increasingly using the Bonneville Dam tailrace as a foraging area, presumably because the adult Chinook, steelhead, and lamprey upon which they feed are concentrated and delayed in this area as they seek entrance to the dam's adult fishways.

2.2.2 Juvenile Passage

Delay

Prior to the development of mainstem dams (c. 1938–1975), the mainstem migratory corridor was free-flowing with high velocities and a broad complex of habitats including rapids, short chutes, falls, riffles, and pools. It is not known how long it took juvenile salmon and steelhead to traverse the free-flowing river. Today, median travel times for yearling Chinook from the Lower Granite Dam on the Snake River to Bonneville Dam range from 14 days to 31 days depending on flow conditions, an increase of 40 to 50% over travel times measured in 1966 (Raymond 1968 and 1979), when fish encountered only the four mainstem dams (Williams et al. 2005).

This increased travel time (migration delay) presents an array of potential survival hazards to migrating juvenile salmon and steelhead: increasing their exposure to potential mortality vectors in the reservoirs (e.g. predation, disease, thermals stress), disrupting arrival timing to the estuary (which likely affects predator/prey relationships),[3] depleting energy reserves, potentially causing metabolic problems associated with smoltification (smoltification is the process of metabolic changes required to allow juvenile fish to convert from freshwater to saltwater environments), and for some steelhead and all Chinook salmon, contributing to residualism (a loss of migratory behavior).

[3] During the spring and summer a series of changes occur in the composition of biotic communities the estuary and near-shore ocean environment. The assemblages of species change through time and disrupting arrival timing may increase the exposure of juvenile salmon to predators and/or diminish the availability of prey species to which the fish are adapted.

Migration delays and biological effects of a similar magnitude have likely also occurred in the middle Columbia River as a result of the construction of the middle Columbia PUD projects.

Dam Passage

A substantial proportion of juvenile salmon and steelhead can be killed while migrating through dams, both directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly, through non-fatal injury and disorientation, which leave fish more susceptible to predation and disease and result in delayed mortality. Some juvenile mortality and injury is associated with any route of dam passage, but turbine passage generally has the highest direct mortality rate—8 to 19 percent. Juveniles passing through project spillways, sluiceways and other surface routes generally suffer the lowest direct mortality rates, 2% or less. However, substantially higher mortality rates have been measured through spillways at several mainstem FCRPS projects (Ferguson et al. 2005, NOAA Technical Memoranda NMFS-NWFSC-64).[4]

Additionally, a significant rate of juvenile mortality (approximately 3 to 5%) can occur in project forebays, just upstream of the dams (Axel et al. 2003; Ferguson et al. 2005; Hockersmith 2007), if fish are substantially delayed (median of 15-20 hours) before passing through the dam (Perry et al. 2007).[5] Forebay delay increases the exposure of juveniles to fish and avian predators and increases their exposure time to adverse water quality conditions (e.g. elevated total dissolved gas levels and high water temperatures), where present. (See discussion in NMFS 2008a—Supplemental Comprehensive Analysis, Section 5.1.2.1 for additional information regarding improvements made at the mainstem hydroelectric dams to improve passage since the mid-1990s, including some discussion of how the newly developed surface passage routes are proving effective at reducing forebay delay.)

Predation

The altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions (increased growth rates, increased consumption rates, and enhanced foraging opportunities) for fish predators (see Dam Passage), including northern pikeminnow (*Ptychocheilus oregonensis*), and non-native walleye (*Sander vitreus*) and smallmouth bass (*Micropterus dolomieu*).

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[4] The route-specific mortality rate values given here are averages across several investigations. Higher and lower moralities have been observed and measured route-specific mortality is influenced by an array of factors ranging from the health and species of the test fish to study methods, the performance characteristics and working condition of the system being studied, and environmental conditions.

[5] This study was conducted at McNary Dam; estimates of delay for individual fish ranged from 0 to 172 hours in this study.

Dams also enhance conditions for avian predators - primarily Caspian terns, double-crested cormorants, and several gull species – because these species can more effectively forage in the forebays and tailraces of the mainstem projects than in a more riverine system.

Transportation Program

Following a decade of research that led to the conclusion that in most cases, the average adult return rates of predominantly stream-type salmonids (spring/summer Chinook and steelhead) that were transported as juveniles exceeded the return rates of fish that migrated inriver, the Corps began large-scale juvenile transportation as a management measure in 1975 (Ebel 1980; Ebel et al. 1973; Mighetto and Ebel 1994). Currently, fish collection and transportation systems are operated seasonally at Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam (and at McNary Dam for summer migrating fall Chinook salmon). Most transported fish are barged to release points downstream from Bonneville Dam. When collection numbers become too small for barging to be cost-effective, collected fish are transported via truck. Approximately 60 to 90% of spring migrating smolts (spring/summer Chinook and steelhead) in the Snake River basin have been transported annually (Williams et al. 2005). Higher proportions (>95%) of Snake River migrants are likely to be transported during low water year conditions (defined as years in which spring flows are expected to be less than 65,000 cubic feet per second at Lower Granite Dam). With the addition of surface passage routes at the Snake River dams, far fewer fish may be transported – especially early in the migration season when adult returns from Chinook salmon smolts left to migrate inriver are relatively high (compared to transported fish) [see discussion below] – than has been possible in the past. For example, in 2007 transport rates were estimated to be much lower than previously estimated (approximately 25% for wild and hatchery yearling Chinook salmon and about 41% for wild and hatchery steelhead) (Smith 2008).

Recent data show that the effectiveness of transportation, in terms of the ratio of returning adults to transported juveniles (termed smolt-to-adult return ratio or SAR) from the Snake River, varies among species, season, and collection location (Williams et al. 2005; Scheuerell and Zabel 2007). In general, the SARs of both transported and inriver migrating Snake River spring/summer Chinook salmon and steelhead tend to decrease once the day of arrival below Bonneville Dam passes early May. For steelhead, SARs of transported fish are typically equal to or higher than those of the surviving inriver migrants arriving downstream of Bonneville Dam (transport-to-in-river SAR ratios > 1.0). For spring/summer Chinook salmon, SARs of surviving inriver migrating fish often are substantially higher in early to mid May than those of transported migrants (transport-to-in-river SAR ratios < 1.0). However, in late May and June, the differences are generally diminished such that SARs are nearly equal (transport-to-in-river ratios ≈1.0).[6]

[6] The ISAB (2008) recently reviewed this information and generally agreed with NOAA Fisheries' assessment of the currently available data regarding the relative returns of adult Chinook and steelhead that were either transported or left inriver to migrate as juveniles. However, they advised NOAA Fisheries, the federal Action Agencies, and other regional managers to continue a "spread the risk" approach to spill and transport management to determine if

2.3 Mainstem Hydrologic Conditions

Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow, altered its seasonality, and reduced sediment discharge and turbidity (NRC 1996; Sherwood et al. 1990; Simenstad et al. 1982 and 1990; Weitkamp 1994). Annual spring freshet flows through the Columbia River estuary are about one-half of the pre-development levels that flushed the estuary and carried smolts to sea (Figure 1).

Flow affects juvenile travel time and the distribution of individuals among the various routes of dam passage. In general, the lower the flow through the FCRPS reservoirs, the longer the travel time of juveniles that migrate inriver.[7] The longer juveniles remain in project reservoirs, the greater their exposure to predation, elevated temperatures, disease, and other sources of mortality and injury.

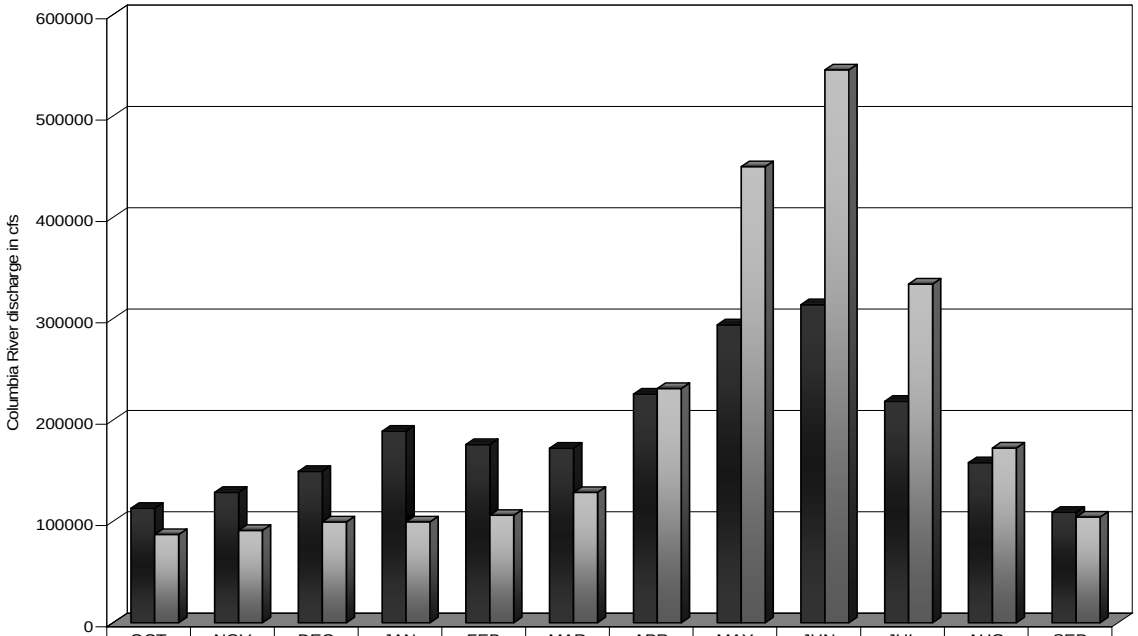
Combined with the influence of reservoirs in the migration corridor, reductions in spring and early summer flows slow juvenile fish emigration, increase their exposure to injury and mortality factors within the reservoirs (e.g. predation, temperature stress, disease, and others), and change the timing of ocean entry.

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these patterns have been altered by recent structural improvements and operations at the mainstem dams and out of concern for potential effects of spring spill and transport operations [proposed in the 2008 FCRPS biop (NMFS 2008b)] on sockeye and lamprey.

[7] At lower river flows a higher proportion of individuals is collected and transported for some ESUs, thereby avoiding the delay associated with inriver hydrosystem passage.

Figure 1. Simulated mean monthly Columbia River flows at Bonneville Dam under current conditions (black columns) versus flows that would have occurred without reservoir management (gray) (water years 1929 –1978. Source: Current Condition Flows – Bonneville Power Administration, HYDSIM model run FRIII_07rerun2004biop.xls; Pre-Development Flows – USBR (1999) Cumulative Hydrologic Effects of Water Use: An Estimate of the Hydrologic Impacts of Water Resource Development in the Columbia River Basin. (In NMFS' (2008a) Supplemental Comprehensive Analysis, Section 5.1.3.)



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

2.4 Mainstem Water Quality

Water quality characteristics of the mainstem Snake and Columbia Rivers are affected by an array of land and water use developments. Water quality characteristics of particular concern are: water temperature, turbidity, total dissolved gas, and chemical pollutants.

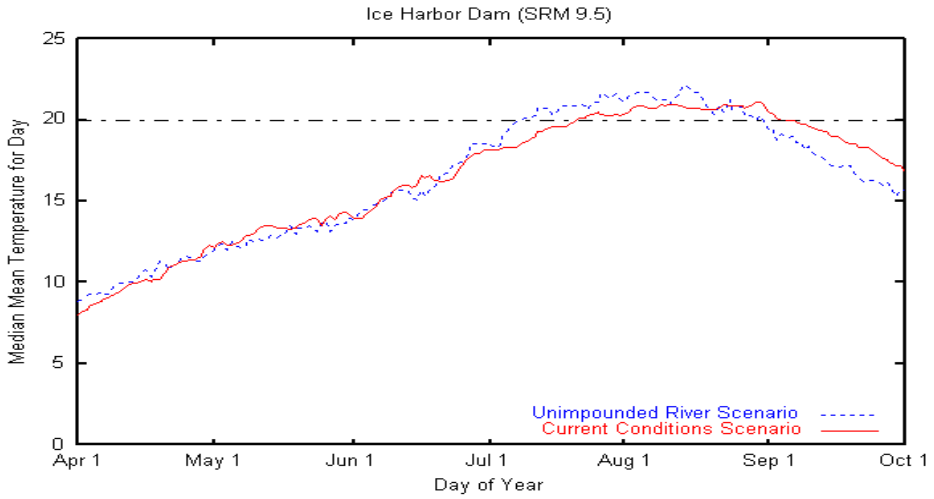
2.4.1 Water Temperature

Changes in water temperatures can have significant implications for anadromous fish survival. Dams and reservoirs influence water temperatures through storage, diversion, and irrigation return flows. Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a fundamental change in the thermal regime of the Snake and

Columbia rivers. As shown in Figure 2, there are three notable differences between the current and the unimpounded river:[8]

- the maximum summer water temperature has been slightly reduced,
- water temperature variability has decreased, and
- post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall. The latter phenomenon is termed thermal inertia.

Figure 2. Median daily Snake River water temperatures (°C) at Ice Harbor Dam before and after development of the four lower Snake River projects (20°C denotes Washington Department of Ecology standard). Source: Perkins and Richmond 2001 in NMFS 2008a.



High water temperatures stress all life stages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmon to stop or delay their migrations and juvenile steelhead to residualize. Warm water temperatures also increase the foraging rate of predatory fish thereby increasing the consumption of smolts.

Though the duration and magnitude of high water temperatures in the migratory corridor is generally less under current, developed conditions than prior to water development, some juvenile fish are exposed to these conditions for a longer period of time due to the adoption of

[8] NOTE: Significant land use practices, including the development of a large number of water storage and diversion projects had already occurred by the 1960s. Therefore, the unimpounded river scenario in this graphic does not be equate to the pre-development condition.

alternative life histories (i.e, juvenile fall Chinook that over-summer in the mainstem reservoirs) or increases in migration travel time.

Coincident with and possibly due to climate change, average annual Columbia Basin air temperatures have increased by about 1 degree C over the past century and water temperatures in the mainstem Snake and Columbia rivers have been affected similarly (ISAB 2007). The influence of this and other large-scale environmental variations are discussed in NMFS 2008a – Supplemental Comprehensive Analysis, Section 5.7.

Also, due to the thermal inertia of the reservoirs (both mainstem and upstream storage projects), atmospheric cooling of water temperatures is delayed in the fall and warming is delayed in the early spring. This can affect Snake River fall Chinook by increasing the exposure of adults to elevated temperatures prior to spawning, resulting in an increased potential of pre-spawning mortality, reduced gamete viability, and subsequent impacts to the development and survival of fish through the egg to fry life stages.

2.4.2 Turbidity

Flow regulation and reservoirs reduces turbidity in the Columbia and Snake rivers. Reduced turbidity can increase predator success through improved prey detection, increasing the susceptibility of smolts to predation. Predation is a substantial contributor to juvenile salmon mortality in reservoirs throughout the Columbia and Snake River migratory corridors.

2.4.3 Total Dissolved Gas

Spill at mainstem dams (either as a means to pass fish or involuntarily in response to over-generational flows) can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated total dissolved gas (TDG) conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids resulting in injury or death. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1-2% when TDG concentrations in the upper water column do not exceed 120% of saturation in FCRPS project tailraces and 115% in project forebays. When those levels are exceeded, there is a corresponding increase in the incidence of GBT symptoms.

However, the effects of total dissolved gas (TDG) supersaturation on aquatic organisms are moderated by depth due to hydrostatic pressure. Each meter of depth compensates for about 10% of gas supersaturation as measured at the water surface. Thus, if the dissolved gas concentration is 120% of supersaturation at the surface, then the condition that the aquatic organism actually experiences at a depth of 2.0 meters is reduced to about 100% (i.e., the fishes tissues will be in equilibrium with the surrounding water and it will not develop gas bubble disease or trauma; Weitkamp 2003).

2.4.4 Pollutants

Background or ambient levels of pollutants in inflows from upstream areas are variable and generally unquantified. Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste to the rivers. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. While these pollutants are not caused by the mainstem Snake and Columbia rivers projects, they are transported through them to the estuary.

Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids including DDT, PCBs, and polyaromatic hydrocarbons (PAH) (NMFS 2001). This data also indicates that juvenile salmonids in the Columbia River estuary have contaminant body burdens in the range where sublethal effects can occur. The sources of exposure are not clear, but may be widespread. Several pesticides and heavy metal contaminants have been detected in Columbia River sediments (ODEQ 2007). In field studies, juvenile salmon from sites in the Pacific Northwest have demonstrated immunosuppression, reduced disease resistance, and reduced growth rates associated with contaminant exposure during their period of estuarine residence (Arkoosh et al. 1991, 1994, 1998; Varanasi et al. 1993; Casillas et al. 1995a, 1995b, and 1998). Some impacts may be occurring within the mainstem Columbia and Snake Rivers, to the extent that juvenile fish are rearing in areas that are contaminated to similar levels as in the estuary.

3.0 Current Recovery Strategies and Actions

Current hydropower programs and operations are the result of completed or ongoing ESA section 7 consultations, Habitat Conservation Plans (HCPs) pursuant to section 10 of the ESA; FERC relicensing proceedings and other regulatory processes. In most cases, hydropower programs and operations are intended to avoid jeopardy and contribute to recovery. There is no distinction between the hydropower actions intended to meet ESA regulatory requirements and those intended purely for recovery.[9]

[9] Recovery cost estimates do not include costs for implementing mainstem actions, first, because of their basinwide scope and applicability to all 13 Columbia Basin salmonid species listed as threatened or endangered, and second, because they are considered "baseline actions," a term that NMFS' NWR ESA recovery plans use for actions already incorporated into other processes, such as section 7 consultations, FERC licensing agreements, and Habitat Conservation Plans, and these costs would occur regardless of the recovery plans.

3.1 Federally Owned and Operated Projects in the Columbia Basin

3.1.1 Federal Columbia River Power System

The Federal Columbia River Power System (FCRPS) consists of 14 projects, each composed of dams, powerhouses, and reservoirs, that are operated as a coordinated system for power production and flood control (while also effectuating other project purposes) on behalf of the Federal government under various Congressional authorities. These projects are: Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams, power plants, and reservoirs in the Snake River basin; Albeni Falls, Hungry Horse, Libby, Grand Coulee and Banks Lake (features of the Columbia Basin Project), and Chief Joseph dams, power plants, and reservoirs in the upper Columbia River basin; and McNary, John Day, The Dalles, and Bonneville dams, power plants, and reservoirs in the lower Columbia River basin.

The plan for operation of the FCRPS through 2018 is described in U.S. Army Corps of Engineers (USACE) et al.'s Comprehensive Analysis Document (USACE et al. 2007a) and Biological Assessment (USACE et al. 2007b) and in NMFS' Supplemental Comprehensive Analysis Document (NMFS 2008a) and Biological Opinion (NMFS 2008b). The following is a general summary of the performance standards, metrics, and targets required in the 2008 Biological Opinion to maintain or improve salmon and steelhead survival in the mainstem migration and rearing corridor and the strategies that will be pursued to achieve these metrics (see RPA 51 in NOAA Fisheries' Reasonable and Prudent Alternative Table of Actions – NMFS 2008b). These actions are intended to address the needs for survival and recovery of all 13 species of ESA-listed salmon and steelhead in the Columbia basin.

- **Adult Passage Performance Standards.** The Actions Agencies must track and confirm that the relatively high levels of adult survival currently observed are maintained or increased through 2018 (see Table 7 of NOAA Fisheries' Reasonable and Prudent Alternatives Table of Actions – NMFS 2008b). These survival rates, which are based on known-origin fish PIT tagged as juveniles, after accounting for known harvest and "natural" rates of straying, range from 81.2% for Snake River fall Chinook salmon up to 91.0% for Snake River spring/summer Chinook salmon (BON to LGR); and from 84.5% for Upper Columbia River steelhead up to 90.1% for Upper Columbia River spring Chinook (BON to MCN).[10]
- **Juvenile Dam Passage Performance Standards.** The Action Agencies must achieve an average Juvenile Dam Passage Performance Standards of 96% survival across Snake

[10] The discrepancy between adult survivals for Upper Columbia River versus Snake River species in the lower Columbia River is recognized and is the subject of directed research, monitoring, and evaluation programs. The objectives of these programs are to determine why the differences exist and what actions might be effective at increasing the survival of the Upper Columbia River species in the lower Columbia River.

River and Lower Columbia River dams for spring Chinook and steelhead and an average of 93% survival across Snake River and Lower Columbia River dams for Snake River sub-yearling fall Chinook.

- **Achieve Juvenile Inriver Survival Performance Metrics.** The Action Agencies must annually measure the survival of inriver migrating fish and compare these numbers with COMPASS model estimates, which will be based on the conditions actually experienced and the expected benefits of completed hydro actions, to assure that survival improvements are occurring as expected.
- **Juvenile System Survival Performance Targets.** The Action Agencies must achieve the expected increase in juvenile fish survival through the hydrosystem (survival to below Bonneville Dam of both transported and inriver migrating fish) that are associated with the proposed hydrosystem actions.

To achieve these metrics, the Action Agencies will pursue the following general objectives and strategies (see NOAA Fisheries' Reasonable and Prudent Alternatives Table of Actions, NMFS 2008b, for specific details):

- Continue collaboration with States and Tribes in the implementation of RPA actions, progress reporting, and adaptive management using fora such as the Regional Implementation Oversight Group.
- Operate the FCRPS to provide flows and water quality to improve juvenile and adult fish survival.[11]
- Modify Columbia and Snake river dams to maximize juvenile and adult fish survival.[12]
- Implement spill and juvenile transportation improvements at Columbia and Snake River dams.
- Operate and maintain facilities at Corps mainstem projects to maintain biological performance.
- Implement piscivorous predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia rivers.

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[11] This includes the operation of storage reservoirs to increase the likelihood of achieving seasonal flow objectives: Spring \ 85 – 100 kcfs at Lower Granite dam, 135 kcfs at Priest Rapids dam, and 220 – 260 kcfs at McNary dam; Summer \ 50-55 kcfs at Lower Granite dam and 200 at McNary. It also includes the continued release of cool water from Dworshak dam during the summer to reduce and maintain temperatures in the lower Snake River.

[12] This includes the design, construction, and testing of structures and operations to provide surface oriented routes of passage which should be beneficial to juvenile migrants and downstream migrating adults (overshoots, fallbacks, or steelhead kelts).

- Implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia rivers.
- Implement marine mammal control measures to increase survival of adult salmonids at Bonneville Dam.
- Provide information needed to support planning and adaptive management and demonstrate accountability related to the implementation of FCRPS ESA hydropower actions for all ESUs (i.e., implement research, monitoring, and evaluation programs for hydropower actions and predator control actions).

In addition to these objectives, the 2008 FCRPS Reasonable and Prudent Alternative Action Table articulates site-specific management actions that will benefit interior Columbia species (see NOAA Fisheries' Reasonable and Prudent Alternatives Table of Actions, NMFS 2008b, for specific details).

3.1.2 U.S. Bureau of Reclamation Projects in the Upper Snake Basin above Brownlee Reservoir

The USBR's proposed actions in its August 2007 Biological Assessment (USBR 2007) addressed operations at 12 projects in the upper Snake River basin: Baker, Boise, Burnt River, Little Wood River, Lucky Peak, Mann Creek, Michaud Flats, Minidoka, Owyhee, Palisades, Ririe, and Vale (collectively, the Upper Snake Project). The proposed actions encompassed USBR's future operations and routine maintenance, including storage and delivery of water, hydropower generation, and releasing water to augment flows for migrating salmonids. NMFS (2008c) prepared a biological opinion on this proposal and concluded that the action would not jeopardize the listed species nor result in the destruction or adverse modification of their designated critical habitat.

The site-specific action of providing salmon flow augmentation is intended to address the needs for survival and recovery of all 13 species of ESA-listed salmon and steelhead in the Columbia basin. Although the physical project operations take place upstream of the migration barrier at Idaho Power Company's Hells Canyon Complex, water released from the upper Snake River project reaches the lower Snake and Columbia rivers where it benefits juvenile salmon and steelhead migrants.

The USBR provides salmon flow augmentation by acquiring water through rental pools and leasing or acquiring natural flow rights. The Nez Perce Water Rights Settlement and the Idaho law that implemented the settlement provide that up to 487,000 acre-feet may be provided for flow augmentation.

3.2 Federal Energy Regulatory Commission-licensed Projects

The Federal Energy Regulatory Commission (FERC) licenses five hydroelectric dams in the middle Columbia reach (i.e., between Chief Joseph Dam and the confluence of the Snake and Columbia rivers): Wells (owned and operated by Douglas County Public Utility District (PUD)), Rocky Reach and Rock Island (Chelan County PUD), and Wanapum and Priest Rapids (Grant County PUD). FERC also licenses Idaho Power Company's (IPC) Hells Canyon Complex in the Snake River basin.

3.2.1 Hydropower Projects Owned and Operated by Chelan and Douglas PUDs

NMFS (2002) entered into three site-specific 50-year anadromous fish agreements and habitat conservation plans (HCPs), one for each of the three mainstem Columbia River hydroelectric projects owned by Chelan (Rocky Reach and Rock Island) and Douglas (Wells) County PUDs, pursuant to section 10 of the Endangered Species Act. The HCPs were developed to protect the five species of Columbia River steelhead and salmon (spring-run Chinook salmon; summer/fall-run Chinook salmon; sockeye salmon, steelhead, and coho salmon, two of which (Upper Columbia River spring-run Chinook salmon and steelhead) were listed as endangered at that time.[13] They satisfied the PUDs' regulatory obligations with respect to anadromous salmonid species under the Federal Power Act, Fish and Wildlife Coordination Act, Pacific Northwest Electric Power Planning and Conservation Act, the essential fish habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act, and Title 77 RCW, as well as the ESA. The agreements set a "no net impact" standard to protect salmon and steelhead at the Wells, Rocky Reach, and Rock Island projects, and provide some degree of certainty for the long-term operation of these projects.[14]

Each of the three HCPs established a standard of 91% combined adult and juvenile passage survival at each project (Wells, Rocky Reach, and Rock Island) (NMFS 2002).[15] The combined survival standard is composed of 93% juvenile and 98% adult project passage survival for all anadromous salmonids. At the time the Incidental Take Permits were issued (August 20, 2003), NMFS estimated that the HCPs represented a 22 to 45% survival improvement potential over the survival levels observed under the historical operations at these projects.

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[13] NMFS (2006) revised its listing of Upper Columbia River steelhead from "endangered" to "threatened" on January 5, 2006.

[14] The HCPs are intended to help prevent conditions that would lead to the need to list additional species of Upper Columbia River salmon and steelhead in the future.

[15] The HCPs allowed the PUDs to compensate for up to 9% project passage mortality through up to 7% hatchery production and up to 2% funding of tributary habitat enhancement projects. That is, the mitigation is intended to match the level of impact.

3.2.2 Hydropower Projects Owned and Operated by Grant County PUD

Grant County PUD's new FERC license includes survival standards required in NMFS (2004) for the Priest Rapids Project (Priest Rapids and Wanapum dams and reservoirs) that are identical to those described above for the HCPs. Furthermore, the following site-specific measures are also included in the new FERC license and are being implemented to ensure that the standards are met:

- Downstream passage measures, including spill through existing and top spill through future units; turbine operations and the installation of advanced turbines; total dissolved gas abatement; avian predator control; and a northern pikeminnow *(Ptychocheilus oregonensis)* removal program

- Continued operation and maintenance, and where needed, improvements to adult fishways at both Priest Rapids and Wanapum dams

- Design and construction of an off-ladder trap and fish-handling facilities at Priest Rapids Dam

- Sluiceway operations for steelhead fallbacks (kelts)

The FERC has completed consultation with NMFS on the terms of a new, 44-year license for the Priest Rapids Project. With respect to site-specific actions for mainstem facilities and operations, FERC adopted the hydro actions in the Reasonable and Prudent Alternative in NMFS' Biological Opinion on Grant County PUD's Interim Protection Plan (NMFS 2004) and in NMFS' February 1, 2008, Biological Opinion (NMFS 2008d) for listed salmon and steelhead, described above.

3.3 Idaho Power Company's Hells Canyon Project

The relicensing of the Hells Canyon Hydroelectric Project is the subject of ongoing administrative proceedings before FERC involving its owner, IPC; Federal, state, and tribal agencies; and other stakeholders. At present, IPC voluntarily operates the project to protect habitat used by fall Chinook salmon for spawning (i.e., by eliminating flow fluctuations), and incubation (i.e., by providing enough flow to prevent the dewatering of redds downstream of the project). As part of an interim settlement agreement in the license proceedings, IPC has agreed to release about 237 thousand acre-feet (kaf) of water – primarily during July - to improve downstream migration conditions (flow) for juvenile fall Chinook salmon (Tucker 2005).

4.0 Survival Rates at Mainstem Federal and Non-Federal Hydro Projects

4.1 Adult Survival

Adult survival estimates presented in this document are based primarily on a simple, straight-forward "conversion rate" method which relies upon the detection and subsequent re-detection of PIT-tagged "known-origin" adults[16] as they migrate upstream through the fishways (some fitted with PIT tag detectors) at the mainstem hydro projects. Detection rates are typically $\geq$ 99% for an individual PIT tag detector and, because there are typically two or three detectors in series within each of the key fishways –virtually every PIT-tagged adult fish migrating upstream through a mainstem fishways is detected.[17]

Minimum adult survival estimates (or conversion rates) can be calculated as the number of fish re-detected at an upstream project divided by the number of fish initially detected at the downstream project of interest. Estimates of "natural" straying rates and of known harvest are also factored in and the resulting number is the proportion of fish that survived between the two projects. For details regarding this method and how "natural" stray rates and harvest rates were used in these analyses, the reader is advised to read the Adult Survival Estimate Appendix of NOAA's Supplemental Comprehensive Analysis (NMFS 2008a). Otherwise, these estimates capture all sources of mortality manifested within the identified reaches, including those resulting from the existence and operation of the FCRPS, as well as unquantifiable levels of mortality from other potential sources (e.g., unreported or delayed mortality caused by fisheries, marine mammal predator attacks, etc.) and unquantifiable levels of "natural" mortality (i.e., levels of mortality in the migratory corridor that would have occurred "naturally" without human influence).

Adult Survival – Federal Projects

Under the 2008 FCRPS Biological Opinion (NMFS 2008b), the federal action agencies are responsible for ensuring that the relatively high rates of survival currently observed in the Bonneville Dam to Lower Granite Dam (7 dams) reach for Snake River species and Bonneville Dam to McNary Dam (3 dam) reach for Upper Columbia River spring Chinook and steelhead is maintained or increased through 2018. Snake River species, for which the most information is available, were used as surrogates for Middle Columbia River steelhead, and Lower Columbia River species. The average survival estimates, annual estimates (ranges), and additional

[16] "Known-origin" means that the release locations for all PIT tagged juvenile fish are available in the PITAGIS data base – and the general area to which these fish are attempting to migrate as adults is also known.
[17] It should be noted that some adults may avoid detection by migrating past the dams via the locks at the federal projects. This is evidenced by individuals not being detected at a particular dam, but being detected at another dam upstream.

information are provided in Table 1 (Column 3 titled "Adult Surv. – FCRPS") and the information for Snake River and Upper Columbia River species is also summarized in the text below.

The average survival estimate for Snake River fall Chinook salmon between Bonneville Dam and Lower Granite Dam was 81% for those that migrated inriver as juveniles and approximately 75% for those that were transported as juveniles, equating to a per project survival (7 dams) of 97% and 96%, respectively.[18]

The average survival estimate for Snake River spring/summer Chinook salmon between Bonneville Dam and Lower Granite Dam was 91% for those that migrated inriver as juveniles and about 84% for those that were transported as juveniles, equating to a per project survival (7 dams) of 99% and 98%, respectively.

The estimated average survival of Snake River sockeye salmon between Bonneville Dam and Lower Granite Dam was 81% equating to a per project survival (7 dams) of about 97%. No estimate can be made with the available data for those fish transported as juveniles (see Table 1, footnote 3).

The average survival estimate for Snake River steelhead between Bonneville Dam and Lower Granite Dam was 90% for those that migrated inriver as juveniles and approximately 83% for those that were transported as juveniles, equating to a per project survival (7 dams) of 99% and 97%, respectively.

The average survival estimate for Upper Columbia River spring Chinook salmon between Bonneville Dam and McNary Dam was 90% (all of these fish migrate inriver as juveniles), equating to a per project survival (3 dams) of approximately 97%.

The average survival estimate for Upper Columbia River steelhead between Bonneville Dam and McNary Dam was 85% (all of these fish migrate inriver as juveniles), equating to a per project survival (3 dams) of 95%.[19]

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[18] Average per project survival estimates are calculated as Average Survival Estimate ^ 1/n. Average per project survival estimates are useful because they allow for a comparison between species that migrate past different numbers of dams.

[19] Note: The apparent discrepancy between the survival rates of Upper Columbia River spring Chinook salmon and steelhead through a 3 dam reach and Snake River spring/summer Chinook salmon and steelhead through a 7 dam reach is noted in the 2008 FCRPS biological opinion. Reasonable and Prudent Alternative Action 52 requires an investigation into the possible causes of this apparent discrepancy (NMFS 2008b). Once a likely cause is identified, the Action Agencies, NOAA Fisheries and co-managing agencies will develop appropriate corrective actions and a monitoring plan to ensure that the differential survival is minimized or eliminated.

Adult Survival – Non-Federal Projects

Under the terms of the Middle Columbia Habitat Conservation Plans for the Wells, Rocky Reach, and Rock Island projects; and under the 2008 biological opinion for the Priest Rapids Project (Wanapum and Priest Rapids dams, NMFS 2008d), the Public Utility Districts must meet or exceed a per project survival of 98% for all adult migrants. At this time, it appears that the average per project survival between Priest Rapids and Wells Dam is 98.7% and 98.2% for Upper Columbia River spring Chinook salmon and steelhead, respectively. The average survival estimates, annual estimates (ranges), and additional information for Upper Columbia River species are provided in Table 1 (Column 4 titled "Adult Surv. – Mid-Columbia" and Column 5 titled "Adult Surv. - Total) and also summarized in the text below.

The average survival estimate for Upper Columbia River spring Chinook salmon migrating between Priest Rapids and the Wenatchee, Entiat, and Methow rivers is approximately 95%, 96%, and 97%, respectively. This survival multiplied by the Bonneville to McNary survival estimate[20] yields a Bonneville to Wenatchee, Entiat, and Methow river survival estimate of about 85%, 87%, and 88%.

The average survival estimate for Upper Columbia River steelhead migrating between Priest Rapids and the Wenatchee, Entiat, and Methow rivers is approximately 93%, 95%, and 96%, respectively. This survival multiplied by the Bonneville to McNary survival estimate[19] yields a Bonneville to Wenatchee, Entiat, and Methow river survival estimate of about 79%, 80%, and 82%.

4.2 Juvenile Survival

Juvenile survival levels are estimated for two periods (See Tables 2 and 3). The "Current" scenario generally translates to survivals recently observed or estimated (modeled using COMPASS) to have occurred due to operational and configuration changes at the mainstem hydroelectric projects through about 2006. The "Prospective" scenario generally translates to attaining survival levels (if not already attained or exceeded) that are required by the Habitat Conservation Plans for the Wells, Rocky Reach, and Rock Island projects; the 2008 biological opinion for the Priest Rapids project (Wanapum and Priest Rapids Dam) (NMFS 2008d); or modeled using COMASS for the 2008 FCRPS biological opinion (NMFS 2008b). Full attainment of these standards is expected when the FCRPS biological opinion is fully implemented from 2015 to 2018.

[20] A McNary to Priest Rapids (Hanford Reach) survival estimate has not yet been calculated, but is likely less than 100%.

Juvenile survival through the federal projects under both the "Current" and "Prospective" cases was estimated using NOAA Fisheries' COMPASS model. The COMPASS model was populated with the best empirically derived estimates of route-specific passage and survival rates available for juvenile Chinook or steelhead to reflect the "Current" configuration of the hydrosystem. The Federal Action Agencies assessed the likely benefits (specific survival improvements) that should result from additional dam configuration actions required in the 2008 FCRPS biological opinion and these improvements were included in the modeling runs of the "Prospective" scenario. Both the "Current" and "Prospective" configurations and operations were modeled across a 70-year (1928 through 2000) historical water record.

The model provides estimates of survival to below Bonneville Dam for inriver (and transported, if applicable) migrants, proportion of the migrants that would likely be transported (if applicable), and the arrival timing of migrants to the Bonneville dam tailrace for ESA-listed spring and summer Chinook salmon and steelhead from the Snake River, Upper Columbia River, and Middle Columbia River populations.[21] For the purpose of this module, the most relevant pieces of information are likely the survival estimates.

4.2.1 Juvenile Survival – Current

Estimates of "Current" juvenile survival through the federal projects, ranges of expected survival, and proportion of juveniles expected to be transported are provided in Table 2 (Column 3 - Juv. Survival – FCRPS). These results are broken into two categories (expected average flows at Lower Granite Dam of less than 65 kcfs or greater than >65 kcfs) for Snake River populations to display the likely effect of the "full transport" operation that would occur in the low flow years – which occurs in about 19% (13 of 70) of the years modeled. Estimates of survival for juveniles migrating from the Methow, Entiat and Wenatchee rivers are provided in Column 4 – Juv. Survival – Mid-Columbia; and combined survival estimates are provide in Column 5 – Juv. Survival – Total. A brief summary of this information is provided for spring migrating Snake River and Upper Columbia River Chinook salmon and steelhead populations in the text below.

The average juvenile survival estimate for Snake River spring/summer Chinook salmon is 56% in the LGR > 65 kcfs years and 37% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 64% and 95% in these flow conditions, respectively.

[21] Insufficient data, primarily resulting from the multiple life-history strategies exhibited by Snake River fall Chinook salmon, was available to populate the COMPASS model to estimate juvenile fall Chinook survival through the FCRPS projects. Instead, NOAA Fisheries derived survival estimates from Fish Passage Center data (see NMFS 2008a and 2008b).

The average juvenile survival estimate for Snake River steelhead is 39% in the LGR > 65 kcfs years and 8% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 79% and 94% in these flow conditions, respectively.

The average juvenile survival estimate for Upper Columbia River spring Chinook salmon is 67% through the four FCRPS dams in the lower Columbia River, and 68%, 71%, and 77% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 45%, 47%, and 51%, respectively.

The average juvenile survival estimate for Upper Columbia River steelhead is 48% through the four FCRPS dams in the lower Columbia River, and 69%, 72%, and 75% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 33%, 34%, and 36%, respectively.

4.2.2 Juvenile Survival – Prospective

Estimates of "Prospective" juvenile survival through the federal projects, ranges of expected survival, and proportion of juveniles expected to be transported are provided in Table 3 (Column 3 - Juv. Survival – FCRPS). These results are broken into two categories (expected average flows at Lower Granite Dam (LGR) of less than 65 kcfs or greater than >65 kcfs) to display the likely effect of the "full transport" operation that would occur in the low flow years – which occurs in about 19% (13 of 70) of the years modeled. Estimates of survival for juveniles migrating from the Methow, Entiat and Wenatchee rivers are provided in Column 4 – Juv. Survival – Mid-Columbia; and combined survival estimates are provide in Column 5 – Juv. Survival – Total. A brief summary of this information is provided for spring migrating Snake River and Upper Columbia River populations in the text below.

The average juvenile survival estimate for Snake River spring/summer Chinook salmon is 63% in the LGR > 65 kcfs years and 52% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 64% and 95% in these flow conditions, respectively.

The average juvenile survival estimate for Snake River steelhead is 45% in the LGR > 65 kcfs years and 9% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 74% and 89% in these flow conditions, respectively.

The average juvenile survival estimate for Upper Columbia River spring Chinook salmon is 73% through the four FCRPS dams in the lower Columbia River, and 72%, 75%, and 81% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 53%, 55%, and 59%, respectively.

The average juvenile survival estimate for Upper Columbia River steelhead is 53% through the four FCRPS dams in the lower Columbia River, and 75%, 78%, and 81% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 40%, 41%, and 43%, respectively.

Table 1: Recent Adult Survival Estimates for ESA-listed Columbia River Basin Salmon and Steelhead Populations Migrating Past Mainstem Hydroelectric Projects Based on PIT-tagged, Known-Origin Adults.[1]

Species	**Population**	**Adult Surv.[2] – FCRPS** *Reach* **Average** Range *Special Info.*	**Adult Surv. – Mid-Columbia[5]** *Reach* **Average** Range *Special Info.*	**Adult Surv.[2] – Total** **Average** Range *Special Info.*
SR fall Chinook[3]	Single Pop.	***BON – LGR*** **Inriver: 81.0** (58.8 – 98.6) **Transported: 74.9** (62.4 – 94.7)		***BON – LGR*** **Inriver: 81.0** (58.8 – 98.6) **Transported: 74.9** (62.4 – 94.7)
SR spr/sum Chinook[3]	All Pops.	***BON – LGR*** **Inriver: 91.0** 81.6 – 97.9 **Transported: 84.1** *73.7 – 88.0*		***BON – LGR*** **Inriver: 91.0** 81.6 – 97.9 **Transported: 84.1** *73.7 – 88.0*
SR sockeye[3]	Single Pop.	***BON – LGR*** **Inriver: 81.1** 79.1 – 83.2 **Transported: (No Est. Available)**		***BON – LGR*** **Inriver: 81.1** 79.1 – 83.2 **Transported: (No Est. Available)**
SR steelhead[3]	All Pops.	***BON – LGR*** **Inriver: 90.1** 85.6 – 93.8 **Transported: 83.3** *78.2 – 89.8* (BON – LGR)		***BON – LGR*** **Inriver: 90.1** 85.6 – 93.8 **Transported: 83.3** *78.2 – 89.8* (BON – LGR)

Species	Population	Adult Surv.[2] – FCRPS *Reach* Average Range *Special Info.*	Adult Surv. – Mid-Columbia[5] *Reach* Average Range *Special Info.*	Adult Surv.[2] – Total Average Range *Special Info.*
UCR spring Chinook[6]	Methow	***BON - MCN***	***PRD - WEL*** **94.7**	***BON – WEL*** **85.3**
	Entiat	**Inriver: 90.1** 86.1 – 96.1	***PRD - RRE*** **96.2**	***BON – RRE*** **86.7**
	Wenatchee		***PRD – RIS*** **97.4**	***BON – RIS*** **87.8**
UCR steelhead[6]	Methow / Okanogan	***BON - MCN***	***PRD - WEL*** **93.0**	***BON - WEL*** **78.6**
	Entiat	**Inriver: 84.5** 77.6 – 90.7	***PRD - RRE*** **94.7**	***BON - RRE*** **80.0**
	Wenatchee		***PRD – RIS*** **96.4**	***BON – RIS*** **81.5**
MCR steelhead[4,7]	Yakima / Walla Walla	***BON - (MCN, JDA, and TDA)*** **Inriver: 95.6** 93.5 – 97.3		***BON-(MCN, JDA, and TDA)*** **Inriver: 95.6** 93.5 – 97.3
	Umatilla / John Day	**97.0** 95.6 – 98.2		**97.0** 95.6 – 98.2
	Deschutes and BON pool	**98.5** 97.8 - 99.1		**98.5** 97.8 - 99.1
LCR Chinook[4]	Spring-run adults	***BON Pool*** **Inriver: 98.6** 97.1 – 99.7		***BON Pool*** **Inriver: 98.6** 97.1 – 99.7
	Fall-run adults	**96.9** 92.7 – 99.8		**96.9** 92.7 – 99.8
LCR steelhead[4,8]	BON pool	***BON Pool*** **>98.5** >97.8 - >99.1		***BON Pool*** **>98.5** >97.8 - >99.1
CR coho[4]	BON pool	***BON Pool*** **96.9** 92.7 – 99.8		***BON Pool*** **96.9** 92.7 – 99.8
CR chum[4]	BON pool	***BON Pool*** **96.9** 92.7 – 99.8		***BON Pool*** **96.9** 92.7 – 99.8

Sources: NMFS' 1) Supplemental Comprehensive Analysis Document (May 5, 2008a); and 2) Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, 11 bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (May 5, 2008b).

[1] Key to Dams: BON = Bonneville Dam, TDA = The Dalles Dam, JDA = John Day Dam, MCN = McNary Dam, PRD = Priest Rapids Dam, WAN = Wanapum Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam, IHR = Ice Harbor Dam, LMN = Lower Monumental Dam, LGS = Little Goose Dam, and LGR = Lower Granite Dam.

[2] These estimates are based on detections of known origin fish returning to the Columbia River, detected passing Bonneville Dam, and redetected at upstream locations. These estimates have been adjusted to account for estimated harvest and "natural" straying rates of adults within the FCRPS migration corridor, but otherwise capture all other sources of mortality manifested within the identified reaches, including those resulting from the existence and operation of the FCRPS, unquantifiable levels of mortality from other potential sources (e.g., unreported or delayed mortality caused by fisheries, marine mammal predator attacks, etc.), and unquantifiable levels of "natural" mortality (i.e. levels of mortality in the migratory corridor that would have occurred "naturally" without human influence).

[3] Adult survival rates for SR fall Chinook, SR spr/sum Chinook, and SR steelhead are reported separately as either inriver or transported (via barge or truck) to properly reflect their migration history as juveniles. Survival estimates for adult SR sockeye are primarily based on unknown origin (though likely from the Lake Wenatchee or Okanogan River sockeye populations) adults PIT tagged at Bonneville Dam and detected at McNary Dam. The average per dam survival is expanded to a seven dam reach (Bonneville Dam to Lower Granite Dam).

[4] The estimates for these ESUs only apply to those adults migrating to tributaries entering the reservoir upstream of Bonneville Dam, or in the case of MCR steelhead, the adult populations migrating to tributaries entering the Columbia River between Bonneville Dam and McNary Reservoir.

[5] Recent adult survival estimates from Priest Rapids to Wells dam are reported in Anchor Env. and Douglas PUD (2008): 93.0% and 94.7% for summer steelhead (2004-2007) and spring Chinook salmon (2003-2007), respectively. The average per project survival estimates ($1/4^{th}$ root of the reach survival estimate) are 98.2% for steelhead and 98.7% for spring Chinook.

[6] NOTE: A separate estimate for the McNary Dam to Priest Rapids Dam reach has not yet been generated. This will be addressed in the next update of the Recovery Planning Hydro Module.

[7] Within the Bonneville pool, Klickitat River and 15 Mile Creek populations of steelhead are part of the Mid Columbia River steelhead Distinct Population Segment.

[8] Within the Bonneville pool, Hood River and Wind River populations of steelhead are part of the Lower Columbia River steelhead Distinct Population Segment.

Table 2. "Current" (2002-2009) Juvenile Survival Estimates for ESA-listed Columbia River Basin Salmon and Steelhead Populations Migrating Inriver Past Mainstem Hydroelectric Projects.[1]

Species	**Population**	**Juv. Survival - FCRPS *Reach*** **Average** (Range) *Special Info.*	**Juv. Survival[3] – Mid-Columbia *Reach*** **Average (**Range) *Special Info.*	**Juv. Survival – Total** **Average (**Range) *Special Info.*
SR fall Chinook	Single Pop.	***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*		***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*
SR spr/sum Chinook	All Pops.	***LGR – BON*** **LGR >65 kcfs** **56.3** (47.5 – 60.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **37.3** (33.8 – 51.3) *≈ 95% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **56.3** (47.5 – 60.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **37.3** (33.8 – 51.3) *≈ 95% of the juveniles would be transported*
SR sockeye[4]	Single Pop.	***LGR - BON*** **LGR >65 kcfs** **36.4** (19.9 – 57.0) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **8.2** (Unknown) *≈ 95% of the juveniles would be transported*		***LGR - BON*** **LGR >65 kcfs** **36.4** (19.9 – 57.0) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **8.2** (Unknown) *≈ 95% of the juveniles would be transported*
SR steelhead	All Pops.	***LGR – BON*** **LGR >65 kcfs** **38.9** (20.3 – 56.9) *≈ 79% of the juveniles would be transported* **LGR <65 kcfs** **7.5** (3.3 – 23.1) *≈ 94% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **38.9** (20.3 – 56.9) *≈ 79% of the juveniles would be transported* **LGR <65 kcfs** **7.5** (3.3 – 23.1) *≈ 94% of the juveniles would be transported*

Species	**Population**	**Juv. Survival - FCRPS *Reach*** **Average** (Range) *Special Info.*	**Juv. Survival[3] – Mid-Columbia *Reach*** **Average (**Range) *Special Info.*	**Juv. Survival – Total** **Average (**Range) *Special Info.*
UCR spring Chinook	Methow Entiat Wentachee	***MCN – BON*** **66.7** (60.9 – 72.9)	***WEL – PRD*** **67.9** ***RRE – PRD*** **70.6** ***RIS – PRD*** **76.7**	***WEL – BON*** **45.3** ***RRE – BON*** **47.1** ***RIS – BON*** **51.2**
UCR steelhead	Methow / Okanogan Entiat Wentachee	***MCN – BON*** **47.9** (16.8 – 67.4)	***WEL – PRD*** **68.9** ***RRE – PRD*** **71.7** ***RIS – PRD*** **74.8**	***WEL – BON*** **33.0** ***RRE – BON*** **34.3** ***RIS – BON*** **35.8**
MCR steelhead[2,5]	 Yakima / Walla Walla Umatilla / John Day Deschutes BON pool	***(MCN, JDA, TDA) – BON*** **47.6** (17.2 – 67.1) **53.6** (23.2 – 72.1) **73.0** (61.5 – 77.6) **90.0** (80.6 – 93.0)		***(MCN, JDA, TDA, BON Pool) – BON*** **47.6** (17.2 – 67.1) **53.6** (23.2 – 72.1) **73.0** (61.5 – 77.6) **90.0** (80.6 – 93.0)
LCR Chinook[2]	BON pool	***BON Pool*** **95.1** (94.4 – 95.9)		***BON Pool*** **95.1** (94.4 – 95.9)
LCR steelhead[2,6]	BON pool	***BON Pool*** **90.6** (80.3 – 94.7)		***BON Pool*** **90.6** (80.3 – 94.7)
CR coho[2]	BON pool	***BON Pool*** **95.1** (94.4 – 95.9)		***BON Pool*** **95.1** (94.4 – 95.9)
CR chum[2]	BON pool	***BON Pool*** **95.1** (94.4 – 95.9)		***BON Pool*** **95.1** (94.4 – 95.9)

Sources: NMFS' 1) Supplemental Comprehensive Analysis Document (May 5, 2008a); and 2) Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, 11 bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (May 5, 2008b).

[1] Key to Dams: BON = Bonneville Dam, TDA = The Dalles Dam, JDA = John Day Dam, MCN = McNary Dam, PRD = Priest Rapids Dam, WAN = Wanapum Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam, IHR = Ice Harbor Dam, LMN = Lower Monumental Dam, LGS = Little Goose Dam, and LGR = Lower Granite Dam.

[2] The estimates for these ESUs only apply to those juveniles migrating from tributaries entering the reservoir upstream of Bonneville Dam, or in the case of MCR steelhead, the juvenile populations migrating from tributaries entering the Columbia River between Bonneville Dam and McNary Reservoir.

[3] Current reach survival estimates for the Mid-Columbia projects are based on the following:

- ***Wells (96.2% for spring Chinook and steelhead)*** - average of the 1998 (99.7%) Chinook study, and 1999 (94.3%) and 2000 (94.6%) steelhead studies as reported in NMFS 2002;

- ***Rocky Reach (92.1% for spring Chinook)*** – average of 2004-2005 studies (93.0% and 91.1%, respectively) as reported in Skalski et al (2006), and ***(95.8% for steelhead)*** - average of 2004-2006 studies (98.3%, 93.0%, and 96.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Rock Island (93.4% for spring Chinook)*** – average of 2002-2004 studies (95.6%, 93.4%, and 91.4%, respectively) as reported in Anchor Env. and Chelan PUD (2004) and Skalski et al (2006), and ***(94.1% for steelhead)*** – average of 2004-2006 studies (96.6%, 91.6%, and 94.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Wanapum and Priest Rapids (82.0% for spring Chinook)*** – estimated using data from PIT tag studies conducted by Chelan PUD in 1998, 2001, 2002, and 2003 as reported in NMFS 2004 – Table A-2 (90.5% per project); and ***(79.5% for steelhead)*** - estimated using data from PIT tag studies conducted by Chelan PUD in 1999 and 2000 as estimated in NMFS 2004 – Table A-2 (89.1% per project).

[4] Williams et al. 2005 provided estimated survival rates ranging for PIT tagged SR sockeye migrating from Lower Granite to McNary Dams in 2000 to 2003. Of these years, 2001, is most representative of the <65 kcfs flow condition – though still conservative because little spill was provided at the mainstem dams for passage in that year. Survival in this year was estimated at 23.9 percent. The remaining years are representative of the >65 kcfs flow condition. Survival rates ranged from 39.7% to 72.5% (average of 56.1%) in these years. An average per project survival was estimated for this reach (LGR to MCN survival ^ (1/4) = 86.5% per project) and then expanded to a Lower Granite to Bonneville Dam (7 project) reach survival estimate (LGR to BON (per project survival estimate ^ 7 = 36.4%).

[5] Within the Bonneville pool, Klickitat River and 15 Mile Creek populations of steelhead are part of the Mid Columbia River steelhead Distinct Population Segment.

[6] Within the Bonneville pool, Hood River and Wind River populations of steelhead are part of the Lower Columbia River steelhead Distinct Population Segment.

Table 3: "Prospective" (approximately 2014 and beyond) Juvenile Survival Estimates for ESA-listed Columbia River Basin Salmon and Steelhead Populations Migrating Inriver Past Mainstem Hydroelectric Projects.[1]

Species	**Population**	**Juv. Survival - FCRPS *Reach*** **Average** (Range) *Special Info.*	**Juv. Survival[3] – Mid-Columbia *Reach*** **Average (**Range) *Special Info.*	**Juv. Survival – Total** **Average (**Range) *Special Info.*
SR fall Chinook	Single Pop.	***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*		***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*
SR spr/sum Chinook	All Pops.	***LGR – BON*** **LGR >65 kcfs** **62.8** (58.0 – 67.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **51.9** (46.7 – 57.2) *≈ 95% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **62.8** (58.0 – 67.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **51.9** (46.7 – 57.2) *≈ 95% of the juveniles would be transported*
SR sockeye[4]	Single Pop.	***LGR - BON*** **LGR >65 kcfs** **42.8** (23.5 – 64.6) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **9.8** (Unknown) *≈ 88% of the juveniles would be transported*		***LGR - BON*** **LGR >65 kcfs** **42.8** (23.5 – 64.6) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **9.8** (Unknown) *≈ 88% of the juveniles would be transported*
SR steelhead	All Pops.	***LGR – BON*** **LGR >65 kcfs** **45.3** (23.9 – 64.5) *≈ 74% of the juveniles would be transported* **LGR <65 kcfs** **9.1** (4.0 – 20.7) *≈ 89% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **45.3** (23.9 – 64.5) *≈ 74% of the juveniles would be transported* **LGR <65 kcfs** **9.1** (4.0 – 20.7) *≈ 89% of the juveniles would be transported*

Species	**Population**	**Juv. Survival - FCRPS *Reach*** **Average** (Range) *Special Info.*	**Juv. Survival[3] – Mid-Columbia *Reach*** **Average (**Range) *Special Info.*	**Juv. Survival – Total** **Average (**Range) *Special Info.*
UCR spring Chinook	Methow	***MCN – BON*** **72.6** (65.4 – 79.6)	***WEL – PRD*** **72.3**	***WEL – BON*** **52.5**
	Entiat		***RRE – PRD*** **75.1**	***RRE – BON*** **54.5**
	Wentachee		***RIS – PRD*** **80.8**	***RIS – BON*** **58.7**
UCR steelhead	Methow / Okanogan	***MCN – BON*** **52.8** (17.3 – 73.8)	***WEL – PRD*** **75.0**	***WEL – BON*** **39.6**
	Entiat		***RRE – PRD*** **78.0**	***RRE – BON*** **41.2**
	Wenatchee		***RIS – PRD*** **81.4**	***RIS – BON*** **43.0**
MCR steelhead[2,5]	Yakima / Walla Walla	***(MCN, JDA, TDA) – BON*** **52.4** (17.9 – 73.3)		***(MCN, JDA, TDA, BON Pool) – BON*** **52.4** (17.9 – 73.3)
	Umatilla / John Day	**57.9** (23.9 – 77.7)		**57.9** (23.9 – 77.7)
	Deschutes	**76.8** (64.5 – 82.2)		**76.8** (64.5 – 82.2)
	BON pool	**90.3** (80.3 – 93.2)		**90.3** (80.3 – 93.2)
LCR Chinook[2]	BON pool	***BON Pool*** **95.5** (94.6 – 96.2)		***BON Pool*** **95.5** (94.6 – 96.2)
LCR steelhead[2,6]	BON pool	***BON Pool*** **90.8** (79.9 – 94.8)		***BON Pool*** **90.8** (79.9 – 94.8)
CR coho[2]	BON pool	***BON Pool*** **95.5** (94.6 – 96.2)		***BON Pool*** **95.5** (94.6 – 96.2)
CR chum[2]	BON pool	***BON Pool*** **95.5** (94.6 – 96.2)		***BON Pool*** **95.5** (94.6 – 96.2)

Sources: NMFS' 1) Supplemental Comprehensive Analysis Document (May 5, 2008a); and 2) Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, 11 bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (May 5, 2008b).

[1] Key to Dams: BON = Bonneville Dam, TDA = The Dalles Dam, JDA = John Day Dam, MCN = McNary Dam, PRD = Priest Rapids Dam, WAN = Wanapum Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam, IHR = Ice Harbor Dam, LMN = Lower Monumental Dam, LGS = Little Goose Dam, and LGR = Lower Granite Dam.

[2] The estimates for these ESUs only apply to those juveniles migrating from tributaries entering the reservoir upstream of Bonneville Dam, or in the case of MCR steelhead, the juvenile populations migrating from tributaries entering the Columbia River between Bonneville Dam and McNary Reservoir.

[3] Prospective reach survival estimates for the Mid-Columbia projects are based on the following:

- ***Wells (96.2% for spring Chinook and steelhead)*** - average of the 1998 (99.7%) Chinook study, and 1999 (94.3%) and 2000 (94.6%) steelhead studies as reported in NMFS 2002;

- ***Rocky Reach (93.0% for spring Chinook)*** – assumes that the minimum survival requirement of the Rocky Reach Habitat Conservation Plan will be met (NMFS 2002), and ***(95.8% for steelhead)*** - average of 2004-2006 studies (98.3%, 93.0%, and 96.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Rock Island (93.4% for spring Chinook)*** – average of 2002-2004 studies (95.6%, 93.4%, and 91.4%, respectively) as reported in Anchor Env. and Chelan PUD (2004) and Skalski et al (2006), and ***(94.1% for steelhead)*** – average of 2004-2006 studies (96.6%, 91.6%, and 94.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Wanapum and Priest Rapids (86.5% for spring Chinook and steelhead)*** – assumes the minimum survival standard (93.0% per project) for these species will be achieved (NOAA 2004).

[4] Williams et al. 2005 provided estimated survival rates ranging for PIT tagged SR sockeye migrating from Lower Granite to McNary Dams in 2000 to 2003. Of these years, 2001, is most representative of the <65 kcfs flow condition – though still conservative because little spill was provided at the mainstem dams for passage in that year. Survival in this year was estimated at 23.9 percent. The remaining years are representative of the >65 kcfs flow condition. Survival rates ranged from 39.7% to 72.5% (average of 56.1%) in these years. An average per project survival was estimated for this reach (LGR to MCN survival ^ (1/4) = 86.5% per project) and then expanded to a Lower Granite to Bonneville Dam (7 project) reach survival estimate (LGR to BON (per project survival estimate ^ 7 = 36.4%). To estimate the expected increase in survival between the "current" and "prospective" conditions, these estimates were adjusted by the estimated survival improvement of SR steelhead in the >65 kcfs flow year condition (45.3% [Prospective] - 38.9% [Current] = 6.4%) resulting in an estimate of 42.8% (36.4% + 6.4%). This was also done for the <65 kcfs flow year condition (9.1% [Prospective] – 7.5% [Current] = 1.6%) resulting in an estimate of 9.8% (8.2% + 1.6%).

[5] Within the Bonneville pool, Klickitat River and 15 Mile Creek populations of steelhead are part of the Mid Columbia River steelhead Distinct Population Segment.

[6] Within the Bonneville pool, Hood River and Wind River populations of steelhead are part of the Lower Columbia River steelhead Distinct Population Segment.

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Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead

National Marine Fisheries Service
Northwest Region

January 2011

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
PORTLAND OFFICE
1201 NE Lloyd Boulevard, Suite 1100
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NOTE TO READERS:

This *Columbia River Estuary Recovery Plan Module* will be the basis of estuary recovery actions for Endangered Species Act-listed salmon and steelhead in the Columbia River Basin. The module will be incorporated by reference into recovery plans for listed Columbia Basin salmon evolutionarily significant units (ESUs) and steelhead distinct population segments (DPSs). It is important to have a unified set of actions for the Columbia River estuary to address the needs of all listed Columbia Basin ESUs and DPSs.

This *Columbia River Estuary Recovery Plan Module* was prepared for NOAA's National Marine Fisheries Service (NMFS) by the Lower Columbia River Estuary Partnership, (contractor) and PC Trask & Associates, Inc. (subcontractor).

DISCLAIMER:

Recovery plans delineate such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of listed species. Plans are published by the National Marine Fisheries Service (NMFS), sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individual or agencies involved in the plan formulation, other than NMFS. They represent the official position of NMFS only after they have been signed by the Assistant Administrator. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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National Marine Fisheries Service (NMFS). 2011. *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead*. NMFS Northwest Region. Portland, OR. January. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor.

Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead

National Marine Fisheries Service
Northwest Region

Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor)

January 2011

Contents

Acknowledgements ..... **vii**
Acronyms and Abbreviations ..... **xi**
Glossary ..... **xiii**
Executive Summary **ES-1**
1 The Columbia River Estuary and Plume **1-1**
Purpose and Development of the Estuary Recovery Plan Module 1-1
Formation and Current Characteristics of the Estuary 1-3
Estuary Reaches 1-4
Columbia River Plume 1-8
Major Land Uses 1-8
Two Centuries of Change 1-9
2 Salmonid Use of the Estuary and Plume **2-1**
Salmonid Species in the Columbia River Basin 2-1
Life History Types and Strategies 2-2
Changes in Life History Diversity 2-3
Relationship of the Estuary to the Columbia River Basin 2-5
Summary 2-8
3 Limiting Factors **3-1**
Determining Estuary Habitat Limiting Factors 3-1
Sources 3-1
Mortality Estimates 3-2
Density-Dependent Mortality 3-3
Habitat-Related Limiting Factors 3-4
Reduced In-Channel Habitat Opportunity 3-5
Reduced Off-Channel Habitat Opportunity 3-6
Reduced Plume Habitat Opportunity 3-8
Limiting Factor: Water Temperature 3-8
Limiting Factor: Stranding 3-10
Food Web-Related Limiting Factors 3-10
Food Source Changes 3-11
Competition and Predation 3-13
Toxic Contaminants 3-15
Limiting Factor: Bioaccumulation Toxicity 3-18
Limiting Factor: Non-Bioaccumulative Toxicity 3-18
Habitat Opportunity, Habitat Quality, and Synergistic Effects 3-21
Prioritization of Limiting Factors 3-22
Summary 3-23
4 Threats to Salmonids **4-1**
Flow-Related Threats 4-2
Threat: Climate Cycles and Global Climate Change 4-4
Threat: Water Withdrawal 4-5
Threat: Flow Regulation 4-6

Sediment-Related Threats 4-6
Threat: Entrapment of Fine Sediment in Reservoirs 4-7
Threat: Impaired Transport of Coarse Sediment 4-7
Threat: Dredging 4-7
Structural Threats 4-8
Threat: Pilings and Pile Dike Structures 4-8
Threat: Dikes and Filling 4-9
Threat: Reservoir-Related Temperature Changes 4-10
Threat: Over-Water Structures 4-10
Food Web-Related Threats 4-10
Threat: Reservoir Phytoplankton Production 4-11
Threat: Altered Predator/Prey Relationships 4-11
Threat: Ship Ballast Practices 4-12
Water Quality-Related Threats 4-13
Threat: Agricultural Practices 4-14
Threat: Urban and Industrial Practices 4-14
Other Threats 4-15
Threat: Riparian Practices 4-15
Threat: Ship Wakes 4-16
Prioritization of Threats 4-16
Summary 4-20
5 Management Actions 5-1
Identification of Management Actions 5-1
Other Recommended Management Actions 5-4
Evaluation of Management Actions: Constraints to Implementation 5-6
Evaluation of Management Actions: Survival Improvement Targets 5-33
Estimating Juvenile Mortality in the Estuary and Plume 5-33
Establishing Survival Improvement Targets 5-34
Assigning Survival Improvement Targets to Recovery Actions 5-37
Uses of the Survival Improvement Targets 5-38
Evaluation of Management Actions: Costs and Schedule 5-41
Summary 5-68
6 Research, Monitoring, and Evaluation 6-1
RME Framework 6-2
Status and Trends Monitoring 6-2
Action Effectiveness Research 6-5
Critical Uncertainties Research 6-6
Implementation and Compliance Monitoring 6-7
Adaptive Management Approach 6-7
Coordination 6-8
Data and Information Management 6-9
Synthesis, Reporting, and Evaluation 6-10
Existing Programs and Projects and Additional Monitoring Needs 6-10
Existing Programs and Projects 6-10
RME Needs, Existing Project Coverage, and Recommended Projects 6-11
Monitoring Recommendations 6-11
Estimated Costs 6-11

Summary 6-11
7 Perspectives on Implementation 7-1
Putting the Estuary in Context 7-1
Factors That Influence Decision Making 7-2
Significance of Constraints to Implementation 7-2
Management Actions Offering the Greatest Survival Benefits 7-4
Costs for Constrained Implementation of Management Actions 7-7
Cost-Effectiveness of Management Actions 7-9
Improving Ecosystem Health 7-11
Implementation Issues 7-15
Relationship of the FCRPS BiOp to the Estuary Module 7-15
Preparation for Decision Making 7-16
8 References 8-1

Appendixes

A Selected Threats to Salmonids by Reach
B Development of Survival Improvement Targets

Tables

ES-1 Management Actions to Address Threats ES-7
ES-2 Management Actions Important for Survival of Ocean- and Stream-Type Salmonids ES-10
2-1 Characteristics of Ocean- and Stream-Type Salmonids 2-2
2-2 Life History Strategies and Their Attributes 2-4
2-3 Linkage between Salmonid ESU, Dominant Life History Type, and Life History Strategy 2-5
3-1 Impact of Limiting Factors on Ocean- and Stream-Type Salmonids 3-24
3-2 Limiting Factor Prioritization 3-25
4-1 Linkages Between Limiting Factors and Threats to Ocean- and Stream-Type Salmonids 4-17
4-2 Prioritization of Threats to Ocean- and Stream-Type Salmonids 4-20
5-1 Management Actions to Address Threats 5-2
5-2 Constraints to Implementation of Management Actions 5-8
5-3 Summary of Constraints to Implementation of Management Actions 5-31
5-4 Estimated Mortality Rates, Survival Rates, and Survival Improvement Targets for Wild, ESA-Listed Juveniles 5-35
5-5 Survival Improvement Targets Allocated to Management Actions 5-39
5-6 Estimated Cost and Schedule 5-44
5-7 Summary of Costs of Management Actions 5-67
6-1 Monitoring Plans Applicable to Estuary RME 6-3
6-2 Ongoing Monitoring Programs Applicable to Estuary RME (as of July 2009) 6-13
6-3 Ongoing Projects Addressing Estuary RME (as of July 2009) 6-15
6-4 Management Actions, Associated Monitoring Needs, and Existing Coverage 6-17
6-5 Recommended New RME Projects 6-20
6-6 Monitoring Guidance for Estuary Recovery Plan Module RME 6-21

6-7 Estimated Cost and Schedule 6-27
7-1 Management Actions Sorted by Degree of Constraint 7-3
7-2 Management Actions Sorted by Benefit to Stream-type Juveniles 7-5
7-3 Management Actions Sorted by Benefit to Ocean-type Juveniles 7-6
7-4 Management Actions Sorted by Estimated Cost 7-8
7-5 Management Actions Sorted by Cost/Survival Index 7-10

Figures

ES-1 Listed Pacific Northwest ESUs ES-2
1-1 The Columbia River Estuary and Its Major Tributaries 1-4
1-2 Lower Columbia River Estuary Reaches 1-5
1-3 Plume Front 1-9
2-1 Historical and Contemporary Early Life History Types of Chinook Salmon in the Columbia River Estuary 2-7
3-1 Diked Areas in the Columbia River Estuary 3-7
3-2 Temperatures of Water Entering the Estuary 3-9
3-3 Conceptual Model of the Columbia River Estuary Food Web 3-12
3-4 Concentrations of PCBs in the Stomach Contents of Subyearling Fall Chinook 3-20
3-5 Concentrations of DDTs in the Stomach Contents of Subyearling Fall Chinook 3-20
3-6 Concentrations of Total Aromatic Hydrocarbons in the Stomach Contents of Subyearling Fall Chinook 3-21
4-1 Conceptual Model of the Columbia River Estuary 4-2
4-2 Changes in the Annual Columbia River Flow 4-3
4-3 Subtidal, Intertidal, and Above-Tidal Estuarine Wetland Zones 4-9
6-1 NMFS Listing Status Decision Framework 6-8

Acknowledgements

Many agencies, organizations, and individuals contributed to this document through review and comment, technical input, communication, and collaboration. The following entities and individuals, in particular, offered input and advice at key points during development of the estuary recovery plan module. Their assistance is greatly appreciated.

Project Development, Drafting Assistance, Review, and Oversight (alphabetical)

Catherine Corbett	Lower Columbia River Estuary Partnership
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Elizabeth Gaar	National Marine Fisheries Service, Northwest Region
Gary Johnson	Pacific Northwest National Laboratories
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Ann Sihler	Ann Sihler Writing and Editing
Cathy Tortorici	National Marine Fisheries Service, Northwest Region

Technical Review, Data, and Input on Issues such as Prioritization of Limiting Factors, Threats, and Survival Improvement Targets (alphabetical)

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Other Input and Technical Assistance (alphabetical)

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Larry Lestelle	Northwest Biostream
Bridgette Lohrman	National Marine Fisheries Service, Northwest Region
Naomi Lundberg	National Marine Fisheries Service, Office of Protected Resources
Keith Marcoe	Lower Columbia River Estuary Partnership
Deb Marriott	Lower Columbia River Estuary Partnership
Phil Miller	Washington State Governor's Salmon Recovery Office
Oregon Lower Columbia River Recovery Plan Stakeholder and Planning Teams	
Oregon Mid-Columbia Steelhead Sounding Board	
Larissa Plants	National Marine Fisheries Service, Office of Protected Resources
Mark Plummer	National Marine Fisheries Service, Northwest Fisheries Science Center

Susan Pultz	National Marine Fisheries Service, Office of Protected Resources
Dan Roby	U.S. Geological Survey
Upper Willamette Recovery Plan Stakeholder Team	

Acronyms and Abbreviations

BACI	before-after-control-impact
BiOp	Biological Opinion
BMP	best management practice
BMPs	best management practices
cfs	cubic feet per second
CRE	Columbia River estuary
CSMEP	Collaborative Systemwide Monitoring and Evaluation Project
DDT	dichlorodiphenyltricholoroethane
DEQ	Oregon Department of Environmental Quality
DPS	distinct population segment
EDT	Ecosystem Diagnosis and Treatment
ENSO	El Niño/Southern Oscillation
EPA	U.S. Environmental Protection Agency
ERME	estuary research, monitoring, and evaluation
ESA	Endangered Species Act
ESU	evolutionarily significant unit
ETM	estuarine turbidity maximum
FCRPS	Federal Columbia River Power System
GIS	geographic information system
HUC	hydrologic unit code
ISAP	Independent Science Advisory Panel
ISRP	Independent Science Review Panel
LCFRB	Lower Columbia Fish Recovery Board
LCRANS	Lower Columbia River Aquatic Nonindigenous Species Survey
LIDAR	Light Detection and Ranging
MMPA	Marine Mammal Protection Act
MR&E	monitoring, research, and evaluation
NASQAN	National Stream Quality Accounting Network
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls

PDO	Pacific Decadel Oscillation
PIT	passive integrated transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
RM	river mile
RME	research, monitoring, and evaluation
TMDL	total maximum daily load
VGP	vessel general permit
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife

Glossary

Accretion: The accumulation of sediment deposited by natural fluid flow processes.

Alevins: Salmonids at the life stage between egg and fry.

Amphipods: Benthic invertebrates, particularly the amphipod *Americorophium salmonis,* which is found in intertidal and shallow subtidal habitats of the Columbia River estuary and is seasonally important in the diet of juvenile salmonids.

Ancient marshes: Marshes formed between 6,000 and 10,000 years ago.

Bar: A ridge or succession of ridges of sand or other substances, especially a formation extending across the mouth of a river or harbor that may obstruct navigation.

Bathymetry: The measure of the depths of oceans, seas, or other large bodies of water.

Beach erosion: The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.

Beach nourishment: The process of replenishing a beach by artificial means, such as through deposition of dredged materials; also called beach replenishment or beach feeding.

Bedload: Sand that rolls and bounces along the surface of the riverbed, usually downstream, although there may be a small displacement toward deeper water caused by the side slopes of the riverbed. In sandy riverbeds, bedload transport shapes the bed into a series of sand waves.

Beneficial use: Placement or use of dredged material for some productive purpose. Examples of beneficial uses include habitat development, beach nourishment, aquaculture, parks and recreation, shoreline stabilization, and erosion control.

Benthic: Of or relating to the bottom of a body of water.

Buffer area: A parcel or strip of land that is designed and designated to permanently remain vegetated in an undisturbed and natural condition to protect an adjacent aquatic or wetland site from upland impacts, to provide habitat for wildlife.

Centennial marshes: Marshes formed over the last century.

Continental shelf: The zone bordering a continent extending from the line of permanent immersion to the depth (usually about 100 to 200 meters) at which there is a marked or steep descent toward greater depths.

Delta: An alluvial deposit, usually triangular, at the mouth of a river. It is normally built up only where there is no tidal or current action capable of removing the sediment as fast as it is deposited.

Deposition: The deposit of sediment in an area through natural means, such as wave action or currents, or mechanical means.

Detritus: A loose mixture of organic material (dead plants and animals) and inorganic material (rock fragments) that results directly from disintegration of the material.

Dikes: Earthen walls constructed to contain water; sometimes constructed around dredged material disposal sites but more commonly constructed as flood protection.

Dredging: The removal or redistribution of sediments from a watercourse.

Ecosystem: A community of organisms in a given area together with their physical environment and its characteristic climate.

El Niño/Southern Oscillation: A shorter term climate effect that alternates between cold and warm phases approximately every 3 to 7 years; is associated with a warm-water current that periodically flows southward along the coast of Ecuador, and the southern oscillation

in the atmosphere; affects climatic and ocean conditions throughout the Pacific region.

Emergent marsh: A wet, springy peatland that occurs along the edges of lakes and streams and is covered by grass-like sedges and fed by minerals washing in from surrounding lands.

Emergent vegetation: Rooted plants that can tolerate some inundation by water and that extend photosynthesis parts above the water surface for at least part of the year; emergent vegetation is intolerant of complete inundation over prolonged periods.

Estuarine turbidity maximum (ETM): A circulation phenomenon in an estuary that traps particles and promotes biochemical, microbial, and ecological processes that sustain an important pathway in the estuary's food web.

Estuary: A semi-enclosed coastal body of water with a free connection to the open ocean in which sea water is diluted with runoff from the land.

Exotic species: A non-native plant or animal deliberately or accidentally introduced into a habitat.

Fill: Sand, sediment, or other earth materials that are placed, deposited, or stockpiled.

Fingerling: A juvenile salmonid less than 1 year old.

Floodplain: A flat tract of land bordering a river, mainly in its lower reaches, and consisting of alluvium deposited by the river during flooding.

Fluvial: Involving running water; usually pertains to stream processes.

Forested wetlands: Wetlands that occur in palustrine and estuarine areas and possess an over story of trees, an understory of young trees or shrubs, and a herbaceous layer.

Freshet: High stream flow caused by rains or snowmelt and resulting in the sudden influx of a large volume of freshwater in the estuary.

Fresh water: Water that is less than 0.5 part salt per thousand.

Fry: Juvenile salmonids that have absorbed their egg sac.

Genetic diversity: Variation at the level of individual genes (polymorphism); provides a mechanism for populations to adapt to their ever-changing environment.

Habitat: The physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal; the place where an organism naturally lives.

Habitat capacity: A category of habitat assessment metrics, including "habitat attributes that promote juvenile salmon production through conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality" (Fresh et al. 2005).

Habitat connectivity: A measure of how connected or spatially continuous habitats occur in a larger ecosystem.

Habitat opportunity: A category of habitat assessment metrics that evaluate the capability of juvenile salmon to access and benefit from the habitat's capacity (Fresh et al. 2005).

High marsh: A wetland ecosystem influenced by a marsh surface elevation at approximately mean higher high water that is inundated by only the most extreme high tides and is characterized by salt-tolerant emergent vegetation.

Intertidal: Of or relating to the substrate that is exposed and flooded by tides; includes the associated splash zone.

In-water disposal: Placement of dredged material along the riverbed in or adjacent to the navigational channel or in designated in-water sites; commonly referred to as flow-lane disposal.

Limiting factor: Physical, chemical, or biological features that impede species and their independent populations from reaching viability status.

Littoral: Of, relating to, or situated or growing on or near a shore; especially of the sea.

Littoral current: A current running parallel to the beach and generally caused by waves striking the shore at an angle.

Low marsh: A wetland ecosystem characterized by salt-tolerant emergent vegetation and twice-daily inundation of high tides.

Macroinvertebrates: Invertebrates that are of visible size, such as clams and worms.

Marsh: An area of soft, wet, or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

Mean high water: The average height of all high waters over 19 years.

Mean higher high water: The average height of the higher of two unequal daily high tides over 19 years.

Mean low water: The average height of all low waters over 19 years.

Mean lower low water: The average height of the lower of two unequal daily low tides over 19 years.

Macrodetritus: Dead or dying matter from a plant or animal that is visible to the unaided eye; usually larger than 1 to 2 mm in diameter.

Microdetritus: Dead or dying matter from a plant or animal; usually smaller than 1 to 2 mm in diameter.

Navigational channels: Channels in estuaries and other water bodies that are created, deepened, and maintained by dredging to enable vessels to navigate safely between, into and out of ports, harbors, and marinas without running aground.

Nearshore: An indefinite zone extending seaward from the shoreline well beyond the breaker zone.

Ocean-type: Of or relating to salmonid juveniles that enter the estuary as fry or fingerlings and stay in the estuary for weeks or months before entering the ocean; examples are chum and subyearling Chinook.

Oligohaline: Of or relating to water having low salinity.

Overbank flooding: Out-of-bank flooding resulting from flow events that exceed the bankfull.

Over-water structures: Human-made structures, such as a pier, that extend over all or part of the surface of a body of water.

Pacific Decadal Oscillation: A longer term climate effect that alternates between cold and warm phases approximately every 30 years.

Pelagic: Pertaining to the open ocean.

Pinnipeds: Seals, sea lions, and walruses that belong to the taxonomic suborder called Pinnipedia, or the "fin-footed." Pinnipeds are carnivorous aquatic mammals that use flippers for movement on land and in the water. The pinnipeds referred to in this document are Pacific harbor seals, California sea lions, and Stellar sea lions.

Pier: A structure, usually of open construction, extending out into the water from the shore, to serve as a landing place, recreational facility, etc., rather than to afford coastal protection.

Piling: A long, heavy timber or section of concrete or metal that is driven into the earth or bottom of a water body to serve as a structural support or protection.

Pile dike: Two parallel rows of piling that are tied together and extend 300 to 500 feet into the river.

Pile dike field: Several pile dikes spaced about 1,200 to 1,500 feet apart, typically built to concentrate flow and stabilize the channel; within the dike field, current velocities are slowed and flow is deflected away from the river bank.

Plume: The layer of Columbia River water in the nearshore Pacific Ocean.

Polychlorinated biphenyls (PCBs): A group of synthetic, toxic industrial chemical compounds that are chemically inert and not biodegradable; they once were used in making paint and electrical transformers.

Polycyclic aromatic hydrocarbons (PAHs): A group of more than 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat.

Population: A distinct breeding unit of a species that exhibits similar life history strategies.

Redds: Spawning nests used by trout and salmon.

Revetment: A facing of stone, concrete, etc., to protect an embankment or shore structure from erosion by wave action or currents.

Salmonid: Any member of the family Salmonidae, which includes the salmon, trout, char, whitefishes, and grayling of North America.

Salmonid population viability: Measure of the status of anadromous salmonids that uses four performance criteria: abundance, productivity, spatial distribution, and diversity.

Sand: An unconsolidated mixture of inorganic soil (possibly including disintegrated shells and coral) consisting of small but easily distinguishable grains ranging in size from about 0.062 mm to 2.0 mm.

Sand waves: Waves of sand on the bottom of a riverbed that move in response to river discharge and bedload transport. In the Columbia, sand waves cover the riverbed and are typically 4 to 8 feet high and 300 to 400 feet long. When the river discharge is less than 300,000 cfs, sand waves move only a few feet per day; however, when discharge exceeds 400,000 cfs, sand wave movement can reach 20 feet per day or more.

Scour: The removal of underwater material by waves and currents, especially at the base or toe of a structure.

Sediment: Material in suspension in water or recently deposited from suspension; in the plural, all kinds of deposits from the waters of streams, lakes, or seas.

Sediment trapping: The capture of sediments behind structures such as dams and shoreline armoring, which restrict sediments from entering systems.

Shallows and flats: Areas from the 6-foot bathymetric contour line up to the edge of tidal marsh or swamp vegetation, or to mean higher high water where vegetation is absent.

Shoaling: A gradual decrease in water depth as the result of the accretion of sediments.

Smolts: Juvenile salmonids that have left their natal stream and are headed downriver toward the ocean.

Stream-type: Of or relating to salmonid juveniles that rear in freshwater for a year or more before entering the ocean.

Threat: A human action or natural event that causes or contributes to limiting factors; threats may be caused by past, present, or future actions or events.

Tidal marshes: Areas dominated by emergent vegetation and low shrubs; are typically found from mean lower low water to slightly above mean higher high water, although they are rare at the lowest elevations.

Tidal prism: The difference in the volume of water covering an area, such as a wetland, during low tide and the volume covering it during the subsequent high tide.

Tidal swamps: Shrub- and forest-dominated wetlands that extend up to the line of non-aquatic vegetation (the line at which excess water ceases to be a factor controlling the composition of the vegetation); tidal swamps may be of sufficiently high elevation that they are inundated only during spring tides, but they may also extend down below mean higher high water.

Tide: The periodic rising and falling of the water that results from gravitational attraction of the moon and sun acting on the rotating earth.

Turbidity: A condition in bodies of water where high sediment loads cause clouding of the water to varying extents; turbidity is an optical phenomenon and does not necessarily

have a direct linear relationship to particulate concentration.

Viable salmonid population: An independent population of Pacific salmon or steelhead trout that has a negligible (generally ≤5 percent) risk of extinction over a 100-year timeframe.

Executive Summary

What is the Estuary Recovery Module?

This estuary recovery plan module is one element of a larger regional planning effort to develop recovery plans for Endangered Species Act-listed salmon and steelhead trout in the Columbia River basin. Recovery plans are being developed for each of the 13 listed evolutionarily significant units (ESUs) in the Columbia.[1] Figure ES-1 shows the 13 listed ESUs in the Columbia River basin grouped by region. The regions include the Lower Columbia, Upper Willamette, Middle Columbia, Snake, and Upper Columbia River ESUs. Within each of the regions, the ESUs have unique geographical boundaries that are based on similarities among populations.

This estuary recovery plan module complements other recovery plans in the region. The planning area for the module is all tidally influenced areas of the Columbia River. The upstream boundary of this area is Bonneville Dam, at River Mile 146, and the downstream boundary includes the Columbia River plume.[2] With few exceptions, the module's focus is limited to habitat conditions and processes in the Columbia River estuary and plume, rather than hatchery or harvest practices, hydroelectricity production, or tributary habitats in the Columbia River basin. The goal of the module is to identify and prioritize management actions that, if implemented, would reduce the impacts of limiting factors, meaning the physical, biological, or chemical conditions that impede salmon and steelhead survival during their migration through and rearing in the estuary and plume ecosystems. To accomplish this, changes in the physical, biological, or chemical conditions in the estuary are reviewed for their potential to affect salmon and steelhead. Then, the underlying causes of limiting factors are identified and prioritized based on the significance of the limiting factor and each cause's contribution to one or more limiting factors. These causes are referred to as threats and can be either human or environmental in origin. Finally, management actions are identified that are intended to reduce the threats and increase the survival potential of salmon and steelhead during estuarine rearing and migration. Costs are developed for each of the actions using an estimated level of effort to implement actions.

This estuary recovery plan module is intended to help answer questions about the degree to which the estuary and plume can contribute to salmon and steelhead recovery efforts throughout the Columbia River basin. The state of the science surrounding the estuary and plume is such that quantitative answers to questions about estuarine ecology are not necessarily available at this time. This is true in part because of the complexity of the ecological processes in the estuary and plume. However, it is also true because the Columbia River estuary and plume are only now being studied at a level of detail that

[1] NOAA's National Marine Fisheries Service (NMFS) has revised its species determinations for West Coast steelhead under the Endangered Species Act (ESA), delineating steelhead-only "distinct population segments" (DPSs). The former steelhead ESUs included both anadromous steelhead trout and resident, non-anadromous rainbow trout, but NMFS listed only the anadromous steelhead. The steelhead DPS does not include rainbow trout, which are under the jurisdiction of the U.S. Fish and Wildlife Service. In January 2006, NMFS listed five Columbia River basin steelhead DPSs as threatened (71 FR 834). To avoid confusion, references to ESUs in this estuary recovery plan module imply the steelhead DPSs as well.

[2] See Figures 1-1 and 1-2 for a depiction of the planning area.

allows knowledge about this portion of the Columbia River ecosystem to be integrated into the understanding of life history patterns that have been well documented in the upstream portions of the basin.

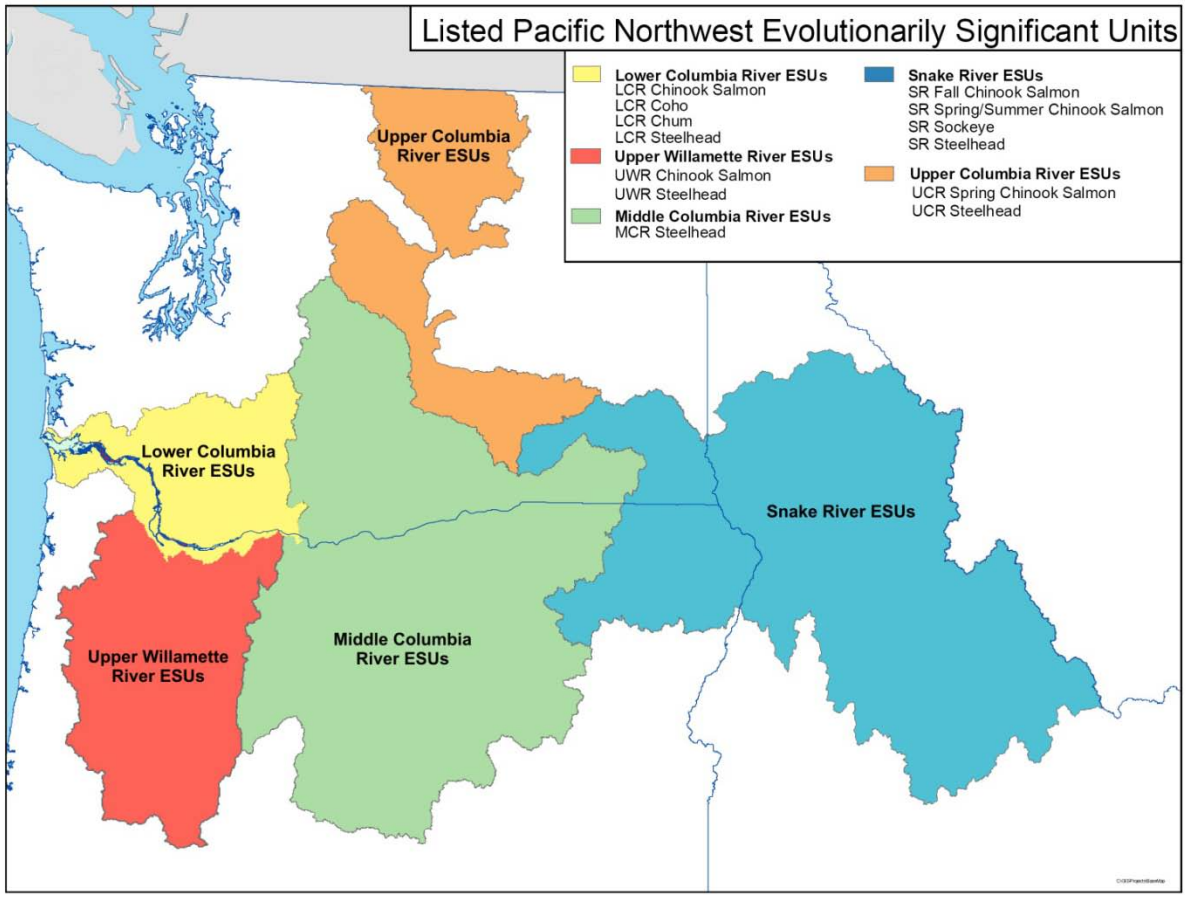


FIGURE ES-1
Listed Pacific Northwest ESUs

This estuary recovery plan module is a synthesis of diverse literature sources and the direct input of estuary scientists. The module was developed by the Lower Columbia Estuary Partnership and a private consultant, PC Trask & Associates, Inc. The primary author was PC Trask & Associates, Inc., with significant involvement from Lower Columbia River Estuary Partnership staff. The author used several key documents as a platform for the module. One of those documents is the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan," which the Lower Columbia River Estuary Partnership developed, along with its supplement, for the Northwest Power and Conservation Council's *Columbia River Basin Fish and Wildlife Program* (Northwest Power and Conservation Council 2004). In 2005, the Northwest Fisheries Science Center of NOAA's National Marine Fisheries Service (NMFS) produced two important technical memoranda for the estuary: *Salmon at River's End* (Bottom et al. 2005) and *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead* (Fresh et al. 2005). The author used these two memoranda extensively and consulted other sources as well, including many primary sources. Area experts from the

NMFS Northwest Fisheries Science Center and Northwest Regional Office, the Lower Columbia River Estuary Partnership, and the Lower Columbia Fish Recovery Board provided input and advice on scoring and evaluation processes. Additionally, the author briefed the Northwest Power and Conservation Council, Mid-Columbia Sounding Board, Upper Willamette Recovery Planning Stakeholder Team, and Lower Columbia River Recovery Planning Stakeholder Team and took their feedback into account when refining the module. Lastly, PC Trask & Associates, Inc., and Lower Columbia River Estuary Partnership staff worked with NMFS Northwest Regional Office staff to revise the module in response to comments received during the public comment period.

Why Are the Estuary and Plume Important?

The Columbia River estuary and plume represent one of three major stages in the life cycle of salmon and steelhead. In tributaries, adults spawn and juveniles rear in freshwater. In the ocean, juveniles grow to adults as they forage in food-rich environments. The estuary is where juveniles and adults undergo vast physiological changes needed to transition to and from saltwater. In addition, a properly functioning estuary provides high growth opportunities and refugia from predators.

But why are the estuary and plume so important? The answer lies in the very reason that salmonids grew in numbers to an estimated 16 million over the past 4,000 years. Salmon and steelhead were successful because they exploited a wide array of the habitat niches available to them. They did this by employing a variety of strategies that allowed them to use many diverse habitats across a wide geographic space. In fact, the distribution of salmon and steelhead historically spanned thousands of river miles throughout the basin.

If this were not remarkable enough, salmon and steelhead's traits allowed them to use habitats at varying times, and this is one of the primary reasons the estuary and plume are so important. Every downstream-migrating juvenile salmon or steelhead must use the habitats of the estuary to complete its life cycle. If the progeny of the 16 million adult salmon and steelhead that historically made use of the estuary had converged on the estuary at one time, there likely would not have been enough habitat and food to sustain them. So they developed strategies to enter the estuary at different times, at different sizes, using unique habitats. In fact, it has been hypothesized that each individual population's use of estuarine habitats is discrete in terms of time and location of use. The implication of this for the estuary and plume today is that the area's habitats must be available through time and space and at sufficient quantities to support more than 150 distinct salmon and steelhead populations, which represent 13 ESUs that use many diverse life history strategies.

The number of adult salmon and steelhead that return to the Columbia River basin each year varies, but in recent years, average returns have been about 1.7 million, with approximately 65 to 75 percent of those fish being of hatchery origin.[3] For 2006, scientists from the NMFS Northwest Fisheries Science Center estimated that about 168 million juveniles would enter the estuary (Ferguson 2006b). This suggests that only 1 percent of the juveniles entering the estuary will return as adults and 99 percent are lost as a result of all the limiting factors (human and natural) in the estuary, plume, nearshore, and ocean.

[3] This is an informal estimate; determining the ratio of hatchery-origin fish with more certainty would require stock-by-stock run calculations averaged over many years.

Understanding the extent to which the estuary and plume contribute to these losses is essential to the ultimate recovery of salmon and steelhead ESUs throughout the basin.

What Is the Condition of the Estuary Now?

Flows, Dikes and Filling, and Sediment

The estuary and plume are considerably degraded compared to 200 years ago. In terms of absolute size, the estuary tidal prism is about 20 percent smaller than it was when Lewis and Clark camped along the Columbia's shore (Northwest Power and Conservation Council 2004). This reduction in estuary size is due mostly to dike and filling practices used to convert the floodplain to agricultural, industrial, commercial, and residential uses. Instream flows entering the estuary also have changed dramatically—there has been a 44 percent decrease in spring freshets or floods, and the annual timing, magnitude, and duration of flows no longer resemble those that historically occurred in the Columbia River (Jay and Kukulka 2003). Changes to flow volume and timing are attributed to hydrosystem regulation; water withdrawal for agricultural, municipal, and industrial purposes; and climate fluctuations. Further alterations in flow are likely to occur during the next century as a result of global climate change, the effects of which are expected to include more precipitation falling as rain rather than snow, less snow storage, and—in the estuary—higher peak flows and reduced late-summer/early-fall stream flows (Independent Scientific Advisory Board 2007).

Flow alterations and dike and filling practices are significant to salmon and steelhead in several ways. Historically, vegetated wetlands within the floodplain supplied the estuary with its base-level food source: macrodetritus. The near elimination of overbank events and the separation of the river from its floodplain have altered the food web by reducing macrodetrital inputs by approximately 84 percent (Bottom et al. 2005). At the same time, phytoplankton detrital sources from upstream reservoirs now dominate the base of the food chain. The substitution of food sources likely has profound effects on the estuary ecosystem. In addition, access to and use of floodplain habitats by ocean-type ESUs (salmonids that typically rear for a shorter time in tributaries and a longer time in the estuary) have been severely compromised through alterations in the presence and availability of these critical habitats.

The timing, magnitude, and duration of flows also have important ramifications to in-channel habitat availability and connectivity. Sand transport along the river bottom is highly correlated to flow. With reductions in the magnitude and duration of flows, erosion and accretion processes no longer function as they have for thousands of years. This may have far-reaching consequences to the estuary, plume, and nearshore lands north and south of the river's mouth. At the same time, upstream dams have prevented sediments from entering the estuary, while dredging activities have exported sand and gravel out of the estuary. Studies have shown that sand is exported from the estuary at a rate three times higher than that at which it enters the estuary. The full impact of these changes is unknown; however, sediment transport is a primary habitat-shaping force that determines the type, location, and availability of habitats distributed in the estuary and plume. In addition, decreases in sediments have improved water clarity and increased the effectiveness of predators that consume juvenile and adult salmon and steelhead.

Water Quality

Water quality in the estuary and plume has been degraded by human practices from within the estuary and also from upstream sources. Today, elevated water temperatures and toxic contaminants both pose risks to salmon and steelhead in the estuary. Summer water temperatures entering the estuary are on average 4° F (2.2° C) warmer today than they were in 1938 (Lower Columbia Fish Recovery Board 2004). The upper thermal tolerance range for cold-water fish, including salmon and steelhead, is about 20° to 24° Celsius (68° to 75° Fahrenheit). Temperatures exceeding this threshold have been occurring earlier in the year and more frequently since 1938 (as measured at Bonneville Dam). Degradation of tributary riparian habitat caused by forest, residential, commercial, and industrial practices, as well as reservoir heating and global climate change are responsible for increased temperatures. During the next century, it is likely that the expected effects of global climate change will continue to increase water temperatures.

Another important indicator of water quality degradation in the estuary is the presence of toxic contaminants. One study of contaminant impacts on juvenile salmon estimated disease-induced mortalities of 1.5 and 9 percent as a result of contaminant stressors for residencies in the Columbia River estuary of 30 to 120 days, respectively (Loge et al. 2005). If this estimate is accurate, threats from contaminants may exceed those from Caspian tern predation.

Toxic contaminants are widespread in the estuary, both geographically and in the food chain, with the urban and industrial portions of the estuary contributing significantly to juvenile salmon's toxic load (Lower Columbia River Estuary Partnership 2007). Some of these contaminants are water-soluble agricultural pesticides and fertilizers, such as simazine, atrazine, and diazinon. Industrial contaminants include polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). Also present are pharmaceuticals, personal care products, brominated fire retardants, and other emerging contaminants. Concentrations of toxic contaminants in the bodies of juvenile salmonids in the estuary sometimes are above levels estimated to cause health effects. In a 2007 study, this was the case for PCBs, PAHs, and DDT, and juveniles showed evidence of exposure to hormone-disrupting compounds (Lower Columbia River Estuary Partnership 2007). Salmon and steelhead experience both short-term exposure to toxic substances and long-term exposure to contaminants that accumulate over time and magnify through the food chain. Even when exposures are sublethal, they can cause significant developmental, behavioral, health, and reproductive impairments. Ocean-type ESUs are more susceptible to bioaccumulation than stream-type ESUs; however, both are equally vulnerable to acute exposures (stream-type ESUs are those ESUs that typically spend longer periods in tributaries and less time in the estuary).

Food Web and Species Interactions

The Columbia River estuary represents a distinct ecosystem that is a unique expression of biological and physical interactions. As physical and biological changes occur in the estuary, the ecosystem responds to those changes. There is general agreement that the estuary ecosystem is degraded and no longer provides the same level of support to native species assemblages that it did historically. Unfortunately, this field of research is perhaps the least understood, and its impact on salmon and steelhead is not well documented or studied.

Limiting factors related to the food web and species interactions can be thought of as the product of all the threats to salmon and steelhead in the estuary. Some examples of food web and species interactions-related limiting factors are easy to understand, but others are subtle and far-reaching. Caspian terns are a good example of an ecosystem shift that is easy to understand. New islands formed through the disposal of dredged materials attracted terns away from their traditional habitats, which may be being degraded. Reduced sediment in the river may have increased terns' efficiency in capturing steelhead juveniles migrating to saltwater at the same time that the birds need additional food for their broods. The result is a predator/prey shift in the estuary that has increased mortality for steelhead juveniles. Double-crested cormorants also prey on juvenile salmonids, in similar numbers as terns.

Other shifts in the ecosystem are more complex, and it can be difficult to understand whether or how they affect salmon and steelhead. For example, the shift in the food base of the estuary—from local macrodetrital sources to imported microdetrital sources such as phytoplankton—has fundamentally changed the food web and species relationships; however, what this means to salmon and steelhead—or, for that matter, to the entire estuarine ecosystem—is unknown. The introduction of exotic species is another poorly understood ecosystem alteration. Examples of exotic species thriving in the estuary include 21 new invertebrates, such as Asian clams and copepods, plant species such as Eurasian water milfoil, and exotic fish such as shad. Shad in particular, because of the sheer tonnage of their biomass, undoubtedly play a large role in the degradation of the estuary ecosystem and may compete with juvenile salmonids for food resources. Natural-origin juvenile salmonids may compete with large pulses of hatchery fish for food and space in the estuary if they overlap in space and time. Given the decreases in habitat opportunity and capacity in the estuary, it may be that too many fish—both salmonids and other species—are competing for too few estuarine resources at key times, with the resulting stressors translating into reduced salmonid survival. It is likely that this density-dependent mortality is manifesting itself in the estuary through limiting factors such as reduced off-channel habitat availability, competition with other fish species, and predation by fish and birds.

Other Threats

The estuary also is influenced by a number of physical structures that contribute to its overall degradation, but the extent of their impacts to salmon and steelhead is poorly understood. Over-water and instream structures in the estuary number in the thousands and alter river circulation patterns, sediment deposition, and light penetration; they also form microhabitats that often benefit predators. In some cases, structures reduce juvenile access to low-velocity habitats. Examples of structures include jetties, pilings, pile dikes, rafts, docks, breakwaters, bulkheads, revetments, groins, and ramps.

Ship wake stranding is an example of another threat to salmon and steelhead in the estuary. A study in 1977 by the Washington Department of Fisheries estimated that more than 150,000 juvenile salmonids, mostly Chinook, were stranded on five test sites as a result of ship bow waves striking shorelines (Bauersfeld 1977). Additional studies since the Bauersfeld study have not documented the same level of mortality. Light Detection and Radar (LIDAR) analysis and results from a new study by the University of Washington and the Portland District of the U.S. Army Corps of Engineers may help characterize this threat in the near future. This threat is most detrimental to ocean-type juvenile fry that are less than 60 millimeters long and that rear inches from shore.

What Can We Do to Improve Salmon and Steelhead Survival?

Identification of Management Actions and Monitoring Activities

This estuary recovery module identifies 23 management actions to improve the survival of salmon and steelhead migrating through and rearing in the estuary and plume environments. Table ES-1 lists these management actions and shows their relationship to threats to salmonid survival; this information is presented by topic, rather than priority.

TABLE ES-1
Management Actions to Address Threats

	Threat	Management Action
Flow-related threats	Climate cycles and global climate change[2]	**CRE[1]-1:** Protect intact riparian areas in the estuary and restore riparian areas that are degraded.[2] **CRE-2:** Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.[2] **CRE-3:** Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.[2]
	Water withdrawal	***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries*
	Flow regulation	**CRE-4**: Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume. ***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.*
Sediment-related threats	Entrapment of fine sediment in reservoirs	**CRE-5:** Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.
	Impaired transport of coarse sediment	**CRE-6:** Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially. **CRE-8:** Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health. ***CRE-4:*** *Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.*
	Dredging	**CRE-7:** Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

[1] CRE = Columbia River estuary.

[2] Study of the impacts of global climate change is an evolving field, and additional research is needed to understand the phenomenon's likely effects on estuarine habitats and processes with specificity. At this time, the Independent Scientific Advisory Board of the Northwest Power and Conservation Council expects that the regional effects of global climate change in the next century will include more precipitation falling as rain rather than snow, reduced snow pack, and late-summer/early-fall stream flows, and associated rises in stream temperature (Independent Scientific Advisory Board 2007). The climate-related management actions in Table ES-1 reflect these expected impacts. Although the management actions clearly would not change the threat of global climate change itself, they have the potential to lessen its impact on salmonids in the estuary. Even if climate cycles and global climate change have effects different from those assumed in this document, the management actions that Table ES-1 associates with climate would provide benefits to salmonids by addressing other threats, such as water withdrawal, urban and industrial practices, and reservoir heating. All three of the management actions associated with climate in Table ES-1 are associated with other threats listed in Table ES-1.

Note: Italics indicate an action's second occurrence in the table, in connection with a different threat.

Threat		Management Action
Structural threats	Pilings and pile dike structures	***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Dikes and filling	**CRE-9:** Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat. **CRE-10:** Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.
	Reservoir-related temperature changes	***CRE-2:*** *Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.*
	Over-water structures	**CRE-11:** Reduce the square footage of over-water structures in the estuary.
Food web-related threats	Increased phytoplankton production	***CRE-10:*** *Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.*
	Altered predator/prey relationships	**CRE-13:** Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids. **CRE-14:** Identify and implement actions to reduce salmonid predation by pinnipeds. **CRE-15:** Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants. **CRE-16:** Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island. **CRE-17:** Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations. **CRE-18:** Reduce the abundance of shad in the estuary. ***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Ship ballast practices	**CRE-19:** Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations ***CRE-7:*** *Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.*
Water quality-related threats	Agricultural practices	**CRE-20:** Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
	Urban and industrial practices	**CRE-21:** Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants. **CRE-22:** Restore or mitigate contaminated sites. **CRE-23:** Implement stormwater best management practices in cities and towns.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
Other threats	Riparian practices	***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.*
	Ship wakes	**CRE-12:** Reduce the effects of vessel wake stranding in the estuary.

[3] Unless otherwise noted, the term *best management practices* is used in this document to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

Research, monitoring, and evaluation (RME) needs related to the 23 management actions are discussed in Chapter 6. As noted there, some of these needs are addressed in an existing document, *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008), while others are identified as new needs specific to the management actions in the module. Together, the existing and new RME activities will provide crucial information on salmonid performance in the estuary, the effectiveness of actions that are implemented in the estuary, associated changes in the ecology of the estuary, and scientific uncertainties that affect implementation of the actions.

Evaluating Management Actions: Relationship of Implementation Constraints to Cost and Survival Improvements

Identifying management actions that could reduce threats to salmon and steelhead as they rear in or migrate through the estuary is an important step toward improving conditions for salmonids during a critical stage in their life cycles. However, actual implementation of management actions is constrained by a variety of factors, such as technical, economic, public health and safety, and property rights considerations. In fact, in some cases it will be impossible to realize an action's full potential because its implementation is constrained by past societal decisions that are functionally irreversible. For example, reclaiming off-channel habitats in the lower Cowlitz River floodplain is constrained by the development of the city of Longview decades ago. An important assumption of the estuary recovery plan module is that the implementation of each of the 23 management actions identified in the module is constrained in some manner.

The module makes another important assumption about implementation: although implementation of actions is constrained, even constrained implementation can make important contributions to the survival of salmonids in the estuary and plume.

It is within the context of these two fundamental assumptions that recovery actions are evaluated in the module, in terms of their costs and potential benefits. The evaluation of survival benefits and costs is highly uncertain because it relies on estimates not only of what is technically feasible, but also of what is socially and politically practical. To help characterize survival improvements, the estuary recovery module uses a planning exercise that involves distributing a plausible survival target across the actions to hypothesize a potential amount of improvement that would result from each action. Costs then are developed by identifying projects for each action and units and per-unit costs for each project. Both the survival improvements and costs reflect assumptions about the constraints to implementation and the degree to which those constraints can be reduced given the technical, social, and political context in the Columbia River basin.

Evaluation Results

The estuary recovery plan module estimates the cost of constrained implementation of all 23 actions over a 25-year time period at $528.05 million. This represents an order-of-magnitude increase over the current level of investment in the estuary and reflects a significant level of effort needed to improve ecosystem health in the estuary and plume over the next 25 years. An additional $64.1 million is identified in Chapter 6 for research, monitoring, and evaluation activities. This effort is necessary because (1) scientific understanding of the estuary and how salmonids respond to conditions there is not yet

mature, and (2) the module proposes some innovative management actions whose effectiveness should be explored before they are fully implemented. Thus the total implementation costs for the module are $592.15 million.

Table ES-2 shows the most important management actions for ocean- and stream-type salmonids that emerged from the analysis and planning exercises in the estuary recovery plan module. Many of these key actions are the same for ocean and stream types.

Implementing the suite of key actions in Table ES-2 for ocean-type salmonids would cost approximately $392 million and be expected to achieve approximately 88 percent of the survival target for ocean-type juveniles. (See Chapter 5 for a description of survival targets.) Implementing the suite of key actions for stream-type salmonids would cost approximately $408 million and be expected to achieve 90 percent of the survival target. Additionally, an estimated annual gain of about 1,000 adult salmon and steelhead is associated with the implementation of CRE-14, "Reduce predation by pinnipeds." The lists of priority actions in Table ES-2 for ocean- and stream-type salmonids contain eight actions that are predicted to benefit both types of salmonids. Implementing this common set of actions would cost approximately $372 million and would be expected to yield survival improvements of roughly 3 million juveniles.

TABLE ES-2
Management Actions Most Important for Survival of Ocean- and Stream-type Salmonids

For Ocean Types	For Stream Types
CRE-01: Protect/restore riparian areas.	CRE-01: Protect/restore riparian areas.
CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.	CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows
CRE-08: Remove or modify pilings and pile dikes.	CRE-08: Remove or modify pilings and pile dikes.
CRE-09: Protect/restore high-quality off-channel habitat.	CRE-09: Protect/restore high-quality off-channel habitat.
CRE-10: Breach, lower, or relocate dikes and levees.	CRE-10: Breach, lower, or relocate dikes and levees.
CRE-13: Manage pikeminnow and other piscivorous fish.	CRE-13: Manage pikeminnow and other piscivorous fish.
CRE-21: Identify and reduce sources of pollutants.	CRE-21: Identify and reduce sources of pollutants.
CRE-22: Restore or mitigate contaminated sites.	CRE-22: Restore or mitigate contaminated sites.
CRE-02: Mitigate/reduce reservoir-related temperature changes.	***CRE-14: Reduce predation by pinnipeds.***
	CRE-16: Redistribute Caspian terns.
	CRE-17: Redistribute cormorants.

Note: Bold-face italics indicate management actions that would benefit primarily ocean- or stream-type salmonids, rather than both types.

Other Implementation Considerations: Life History Diversity, Cost-Effectiveness, and Achieving Maximum Benefit

It is tempting to pick and choose among the management actions, looking for the path of least resistance to achieve the desired survival improvements. For example, using the results of the Chapter 7 survival improvement planning exercise, it appears obvious that significant improvements in the survival of stream-type salmonids can be achieved by reducing threats associated with predators such as terns, cormorants, pikeminnow, and pinnipeds. However,

addressing these threats would improve survival primarily for the dominant life-history strategy displayed by stream-type salmonids; in terms of recovery of ESUs, less dominant stream-type life history strategies also must be addressed. This points to the need to implement additional management actions in the estuary not directly related to predation.

For ocean-type juveniles, management actions that improve the health of the estuarine ecosystem appear to be the linchpin. Ocean-type juveniles reside in the estuary longer than stream types do. As a result, they rely more heavily on a healthy estuarine ecosystem to provide them with food and habitat (Bottom et al 2005). Given the challenges of making wide-scale ecosystem change, significant improvements for ocean-type juveniles may depend largely on three of the most constrained actions: adjusting hydrosystem flows (CRE–4), establishing or improving access to off-channel habitats (CRE-10), and restoring contaminated sites (CRE-22). Although these are some of the most expensive actions, their effects could be far-reaching enough that their potential benefits would be at least commensurate with their high costs.

Finally, because the estuary recovery module (by design) takes an optimistic view about what is possible in terms of reducing the constraints to implementation of management actions, in actuality specific actions probably will not be implemented with the level of effort needed to elicit the desired response. In fact, the most important take-home message of the estuary plan module is that recovery of listed ESUs in the Columbia River may not be possible without properly functioning estuary and plume ecosystems. To achieve a meaningful boost in survival from these ecosystems, every ounce of an action's potential benefit should be explored, and serious consideration should be given to implementing all of the 23 management actions to the fullest extent possible.

CHAPTER 1

The Columbia River Estuary and Plume

Purpose and Development of the Estuary Recovery Plan Module

This estuary recovery plan module is a planning document intended to complement other recovery plans in the region. With few exceptions, the module's focus is limited to habitat conditions and processes in the Columbia River estuary and plume, rather than hatchery or harvest practices, hydroelectricity production, or tributary habitats in the Columbia River basin. The purpose of this estuary recovery plan module is to identify and prioritize habitat-related management actions that, if implemented, would reduce threats to salmon and steelhead in the Columbia River estuary and plume.[1]

Chapter 2 provides background information on salmonid use of the estuary and plume within the context of the entire Columbia River basin. Chapter 3 identifies and prioritizes habitat-related salmon and steelhead limiting factors, and Chapter 4 links these limiting factors to the underlying environmental and human threats that have contributed to declines in abundance in the estuary. Chapter 4 also prioritizes threats based on the priority of the limiting factors they contribute to and their relative contribution to those limiting factors. Chapter 5 describes management actions that have the potential to reduce threats and evaluates the actions in terms of their implementation constraints, potential benefits, and costs. Chapter 6 describes research, monitoring, and evaluation needs, while Chapter 7 integrates elements of the earlier chapters to help characterize scenarios for improving the survival of salmonids as they rear in and migrate through the estuary and plume.

This estuary recovery plan module was developed by PC Trask & Associates, Inc., with participation of staff at the Lower Columbia River Estuary Partnership. The author also coordinated closely with staff at NOAA's National Marine Fisheries Service (NMFS) Northwest Regional Office throughout the module development process and obtained additional guidance and input from NMFS Northwest Fisheries Science Center staff and other regional experts (see Acknowledgements).

In drafting the module, the author reviewed and synthesized information from three main source documents:

- *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon* (Bottom et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center

[1] Although current scientific information on the effects of limiting factors and actions does not differentiate between hatchery- and natural-origin salmon and steelhead, or between salmon and steelhead that are listed under the Endangered Species Act (ESA) and those that are not, the intent of the module is to improve the survival of ESA-listed salmon and steelhead. ESA recovery is determined by the status of naturally produced salmon and steelhead.

- *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability* (Fresh et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center
- "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" and its supplement—Northwest Power and Conservation Council (2004)

NMFS Northwest Regional Office staff considered these documents to be timely, comprehensive, and accurate summaries of existing scientific knowledge about the estuary; they proved particularly valuable in providing information about threats and limiting factors affecting salmonids in the estuary.

To clarify key points or address topics that were not included in Bottom et al. (2005), Fresh et al. (2005), and Northwest Power and Conservation Council (2004), the author reviewed additional literature and contacted researchers whose findings were relevant but as yet unpublished; this included researchers at the NMFS Northwest Fisheries Science Center. Area experts (see Acknowledgements) reviewed and helped refine the author's draft products; thus, the module relies heavily on expert opinion rather than an expert panel or "Delphi" process. The author also worked with NMFS Northwest Regional Office and Lower Columbia River Estuary Partnership staff to further revise the module based on comments received during a *Federal Register* public review period. In summary, the final module is a broader, more comprehensive document than the three key source documents and has evolved with input from a diversity of scientists, other specialists, and the public.

Although the estuary recovery plan module is scientifically based, it is primarily a planning document and has important relationships to other planning processes and documents in the region. In the context of Columbia River basin recovery planning, the estuary module provides information on how conditions in the estuary and plume affect the 13 listed Columbia Basin evolutionarily significant units (ESUs). It was distributed in draft form to recovery planning forums around the Columbia River basin, and presentations on the module were made to Oregon's Mid-Columbia Sounding Board, the Upper Willamette Recovery Planning Stakeholder Team, and the Oregon Lower Columbia River Recovery Planning Stakeholder Team.

In the context of lower Columbia River management plans, the estuary recovery plan module is consistent with information in the Northwest Power and Conservation Council's "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" (in *Columbia River Basin Fish and Wildlife Program*, Northwest Power and Conservation Council 2004), the Lower Columbia River Estuary Partnership's *Comprehensive Conservation and Management Plan*, and the Columbia River Estuary Study Taskforce's Columbia River Estuary Data Development Program. In addition, information in the module was used in the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BiOp) and later incorporated into the 2010 Supplemental BiOp; information from the module also was used in Washington's Lower Columbia Fish Recovery Board planning process, Oregon's Lower Columbia River recovery planning process, and other recovery planning efforts throughout the Columbia River basin.

The process of identifying and prioritizing management actions in the estuary module has inherent difficulties. Although scientific knowledge about the estuary is advancing, it is still

incomplete. In addition, effective management solutions must acknowledge irreversible changes in estuary conditions over time, reflect the social and political will of the region, and focus on the biological and physical needs of the fish. In the final analysis, it is likely that science will never fully explain how every action affects the viability of fish. It will be up to current and future residents of the basin to determine how much they are willing to pay or do without in order to return salmon and steelhead to viable levels.

Formation and Current Characteristics of the Estuary

The geographic scope of the estuary recovery module encompasses areas from Bonneville Dam (River Mile [RM] 146; River Kilometer [RKm] 235) to the mouth of the Columbia River, including the Columbia River plume. The scope includes the lower portion of the Willamette River (from Willamette Falls, at RM 26.6 [RKm 42.6], to the Willamette's confluence with the Columbia River), along with the tidally influenced portions of other tributaries below Bonneville Dam. (Tidal portions of tributaries entering the estuary also are addressed in the Lower Columbia Fish Recovery Board's *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* [2010] and Oregon's *Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead* [ODFW 2010] in a manner consistent with the overall framework of this module.)

The Columbia River estuary is a former river valley that, during the last ice age, was carved to 110 meters (360 feet) below current sea level. As sea levels subsequently rose, the floor of the valley was submerged and began to fill with sediments—initially from eastern drainages and then from the Cascade Range. The Missoula Floods, which occurred roughly 15,000 to 13,000 years ago, filled the valley with sand. This was followed by rapid sea level rise, which increased the size of the estuary and allowed further accumulation of mud and sand. By about 9,500 years ago, the rate of sea level rise had declined, the former river valley had filled with sediments, and most suspended sediment and bed load sand arriving from the Columbia River were being transported through the estuary to marine areas via the action of ebb tides and spring freshets, with some suspended sediment being deposited in floodplains and peripheral bays. This pattern continued to the historical period (Petersen et al. 2003).

The historical (circa 1880) total surface area of the Columbia River estuary has been estimated at up to 186 square miles (482 square kilometers) (Thomas 1983, Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004). The current estuary surface area is approximately 159 square miles (412 square kilometers) (Northwest Power and Conservation Council 2004). The Willamette River is the largest tributary to the lower Columbia River. Other major tributaries originating in the Cascade Mountains include the Sandy River in Oregon and the Washougal, Lewis, Kalama, and Cowlitz rivers in Washington. Coastal range tributaries include the Elochoman and Grays rivers in Washington and the Lewis and Clark, Youngs, and Clatskanie rivers in Oregon. The general geography of the estuary is shown in Figure 1-1.



FIGURE 1-1
The Columbia River Estuary and Its Major Tributaries
(Reprinted from Bottom et al. 2005.)

Tidal impacts in water levels are observed as far upstream as Bonneville Dam at RM 146 (RKm 235). During low flows, reversal of river flow has been measured as far upstream as Oak Point at RM 53 (RKm 84.8). The intrusion of saltwater is generally limited to Harrington Point at RM 23 (RKm 36.8); however, at lower daily flows saltwater intrusion can extend past Pillar Rock at RM 28 (RKm 44.8).

Today, the lowest river flows occur during September and October, when rainfall and snowmelt are lowest (Northwest Power and Conservation Council 2004). The highest flows occur from April to June and result from snowmelt runoff. High flows also occur between November and March and are caused by heavy winter precipitation. Discharge at the mouth of the river typically ranges from 100,000 to 500,000 cubic feet per second (cfs). Historically, unregulated flows were both lower and higher—79,000 and 1 million cfs, respectively (Neal 1972 and Lower Columbia River Estuary Partnership 2002 as cited in Northwest Power and Conservation Council 2004).

Estuary Reaches

For the purposes of this estuary recovery plan module, the estuary is broadly defined to include the entire continuum where tidal forces and river flows interact, regardless of the

extent of saltwater intrusion (Fresh et al. 2005, Northwest Power and Conservation Council 2004). For planning purposes, the upstream boundary is Bonneville Dam and the downstream boundary includes the Columbia River plume. These two divisions—the estuary and plume—have been used extensively in this estuary recovery plan module as distinct zones. Further delineation of the estuary has occurred, including efforts by Thomas (1983), Johnson et al. (2003), and the Lower Columbia River Estuary Partnership (2005).

In this estuary recovery plan module, limiting factors, threats, and management actions are identified at the finest reach level possible. In some cases, this may be as general as making a distinction between the estuary and plume. In other cases, additional definition is available at the reach scale. The Lower Columbia River Estuary Partnership, in conjunction with the University of Washington and U.S. Geological Survey, has developed and is continuing to refine several estuary landscape classifications. Of these overlaying classifications, the estuary recovery module uses the Level 3 Stratum, which organizes the estuary between the mouth and Bonneville Dam into eight lettered reaches (Lower Columbia River Estuary Partnership 2005).

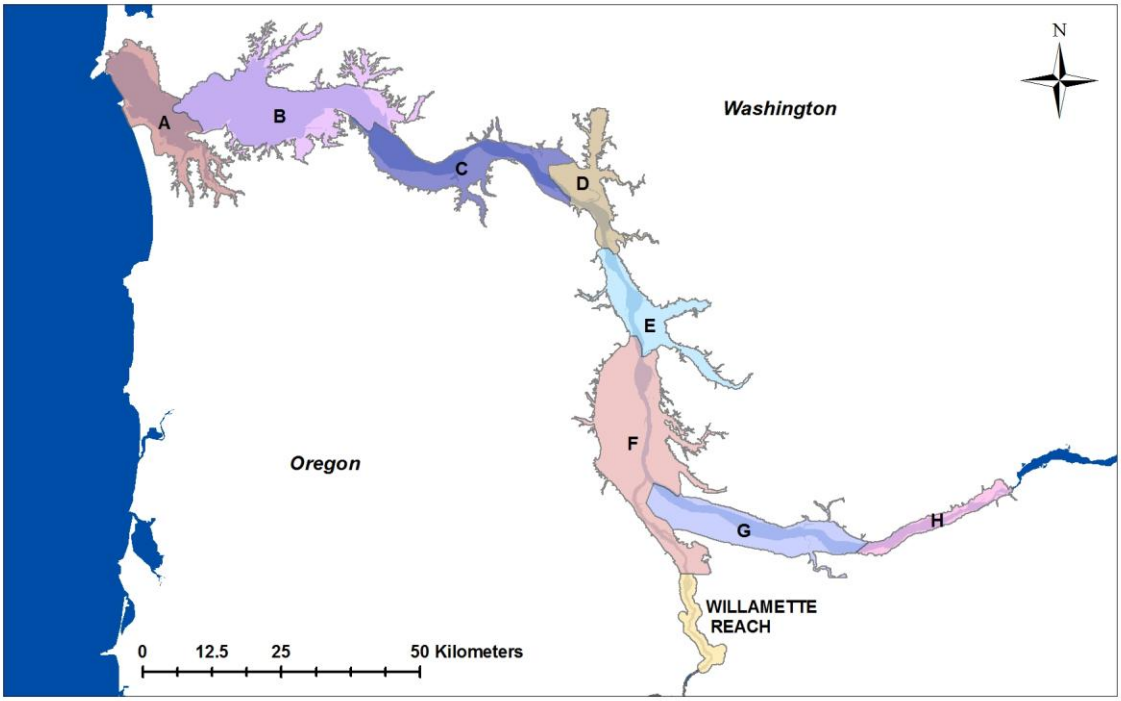


FIGURE 1-2
Lower Columbia River Estuary Reaches
(Adapted from Northwest Power and Conservation Council 2004.)

Figure 1-2 shows these eight reaches, which can be described briefly as follows:

- **Reach A**. This area includes the estuary entrance (Clatsop Spit and Trestle Bay), Bakers Bay, and Youngs Bay. The entrance is dominated by subtidal habitat and has the highest salinity in the estuary. Historically, the estuary entrance was a high-energy area of natural fluvial land forms with a complex of channels, shallow water, and sand bars.

Reach A supports the Columbia River plume, which creates a unique low-salinity, high-productivity environment that extends well into the ocean. The dynamic nature of the entrance area has changed as a result of dredging and the construction of jetties. These activities have limited wave action and the marine supply of sediment.

Historically, ocean currents and wave action made Bakers Bay a high-energy area, but both currents and wave action have been altered by dredging and jetty construction. The migration of mid-channel islands toward the interior of Baker Bay also has sheltered the area from wave action. As a result, tidal marsh habitat has recently started to develop in some areas, although much of the historical tidal marsh and tidal swamp habitat has been lost because of dike construction in the floodplain. Given its proximity to the river mouth, Baker Bay consists primarily of brackish water.

Youngs Bay is characterized by a broad floodplain and historically was abundant in tidal marsh and swamp habitat. Diking and flood control structures have been used to convert floodplain habitat in the area to pasture. The remaining fragmented tidal marsh and tidal swamp habitats in Youngs Bay are thought to be different in structure and vegetative community than historical conditions of these habitats.

- **Reach B**. Reach B generally extends from the Astoria-Meglar Bridge upstream to the westernmost tip of Puget Island. This area includes what has been referred to as the mixing zone (Northwest Power and Conservation Council 2004), along with Grays Bay and Cathlamet Bay. The mixing zone is an area characterized by a network of mid-channel shoals and flats, such as Desdemona and Taylor Sands. It also has the highest variation in salinity within the estuary because of the interactions between tide cycles and river flows. The estuarine turbidity maximum (see p. 3-8), which is created through these interactions, is often located within this area of Reach B. Many islands are found in Reach B, including Tenasillahe, Horseshoe, Marsh, Karlson, Russian, Svensen, Miller Sands, Rice, and Lois islands.

  Grays Bay is found on the Washington side of the river in Reach B. Historically, water circulation in this area was a result of interactions between river flow and tidal intrusion. Pile dike fields constructed adjacent to the main Columbia River navigation channel have decreased circulation in Grays Bay. This circulation change is suspected of causing flooding problems in the Grays and Deep River valley bottoms and may have promoted the beneficial development of tidal marsh habitat in the accreting bay. Dike construction, primarily for pasture conversion, has isolated the main channel from its historical floodplain and eliminated much of the historical tidal swamp habitat.

  Cathlamet Bay is located on the Oregon side of the river in Reach B. This area is characterized by some of the most intact and productive tidal marsh and swamp habitat remaining in the estuary, and a large portion of Cathlamet Bay is protected by the Lewis and Clark National Wildlife Refuge. The western edge of Cathlamet Bay contains part of the brackish oligohaline zone, which is thought to be important during the transition of juvenile anadromous fish from freshwater to saltwater. Portions of Cathlamet Bay have lost substantial acreage of tidal swamp habitat as a result of dike construction. Conversely, tidal marsh habitat has formed along the fringe of dredge disposal locations.

- **Reach C**. This area, which includes deep channels and steep shorelines on the Washington side of the river, extends from the westernmost tip of Puget Island to the western edge of Longview. Historically, Reach C contained significant acres of tidal swamp dominated by sitka spruce. Dike construction and clearing of vegetation have resulted in a substantial loss of tidal marsh habitat on islands and floodplain in the Oregon portion of Reach C. Lord Walker, Hump Fisher, Crims, Wallace and Puget islands are located within Reach C.
- **Reach D**. This area begins west of Longview and ends north of the city of Kalama. Reach D is distinct from the downstream reaches in its geology, vegetation, and climate. It includes flows from the Cowlitz and Kalama rivers. Extensive diking and filling around Longview and the mouth of the Kalama River have significantly reduced access to the floodplain. Islands and shoreline have been extensively modified through the disposal of dredged material. Sediment loading from eruptions of Mount St. Helens have significantly altered hydrology and channel morphology in and downstream of the Cowlitz and Kalama rivers. Dredging and the disposal of sediment from Mount St. Helens have been extensive. The two primary islands in Reach D are Cottonwood and Howard. High levels of polychlorinated biphenyls (PCBs) have been detected in the Longview and Kalama industrial area.
- **Reach E**. This area includes the Columbia River south of the city of Kalama to the confluence with the Lewis River, adjacent to the city of St. Helens, Oregon. The Lewis River system, including the North Fork and East Fork, flows into the Columbia River in Reach E. Sandy, Goat, Deer, Martin, and Burke islands are included in Reach E. Several of these islands, including Sandy and Goat islands, were created through the placement of dredged materials). Extensive diking has occurred on Deer Island and around the city of Woodland, Washington.
- **Reach F**. This area includes the Columbia River south of the confluence with the Lewis River up to and including the mid-point of Hayden Island. Reach F also extends into the Willamette River, to the downstream tip of Ross Island. Reach F is generally rural in character; however, it is located immediately downstream of the most urban/industrial areas in the entire Columbia River. Reach F contains the largest historical floodplain lakes below Bonneville Dam: Sturgeon Lake, at about 3,600 acres, and Vancouver Lake, which is approximately 2,400 acres. The historical floodplain was very wide in Reach F relative to the narrow and constricted channel through the Columbia River Gorge. Islands included in this reach are Bachelor and Sauvie islands. Sloughs include the 13-mile Lake River system and the more than 20-mile-long Multnomah Channel. Scappoose Bay is relatively undiked; however, Sauvie Island and Bachelor Island have been extensively diked. Reach F also includes Portland Harbor, a heavily industrialized stretch of the Willamette River located north of downtown Portland that was listed as a Superfund site in December 2000. Sediments in the river at this site are contaminated with various toxic compounds, including metals, polycyclic aromatic hydrocarbons (PAHs), PCBs, chlorinated pesticides, and dioxin (Oregon Department of Environmental Quality 2008).
- **Reach G**. This area includes the Columbia River west of Hayden Island and extends to just east of Reed Island. Major tributaries include the Washougal and Sandy rivers. The cities of Portland and Vancouver straddle the Columbia River in this reach. Islands included in this reach are Hayden Island, Government Island, Lady Island, and Reed

Island. Extensive diking has reduced the floodplain throughout the reach. Smith and Bybee lakes represent a large floodplain lake system similar to that of Vancouver and Sturgeon lakes in Reach F. Significant numbers of industrial piers and over-water structures line the Columbia rivers in this reach.

- **Reach H**. This area includes the Columbia River from east of Reed Island to the Bonneville Dam. This reach receives flow from many small tributaries, including Gibbons, Duncan, Hamilton, Hardy, and Multnomah creeks. Notable islands in this reach include Ackerman and Skamania islands. Reach H includes the entrance to the Columbia River Gorge, which is characterized by steep slopes. Little diking has occurred in this area, primarily because the steep adjacent slopes on both side of the river have naturally constrained the floodplain.
- **Lower Willamette Reach**. This reach extends upstream from the northern tip of Ross Island to Willamette Falls at RM 26.6 (RKm 42.6). The Lower Willamette reach is highly urbanized, bisecting the city of Portland and flowing past the cities of Milwaukie, Lake Oswego, Gladstone, and Oregon City. Notable islands in the Lower Willamette reach include Ross and Hardtack, Elk Rock, Hog, Cedar, and Goat islands. The primary tributary entering the Lower Willamette reach is the Clackamas River just downstream of Willamette Falls. Other smaller tributaries include Johnson, Tryon, Kellogg, Miller, and Stephens creeks. The shoreline of the Lower Willamette reach has been highly modified for industry, flood control, and other uses. Twelve transportation bridges cross the Willamette River in this reach.

GIS maps of each of the reaches are presented in Appendix A. The maps show additional information such as the locations of pile dikes and some tide gates, the navigation channel, the historical floodplain, diked areas, and dredged material placement sites.

Columbia River Plume

The Columbia River plume is generally defined by a reduced-salinity contour near the ocean surface of approximately 31 parts per thousand (Fresh et al. 2005). In high flows, the plume front is easily recognized by the sharp contrast between the sediment-laden river water and the clearer ocean (see Figure 1-3). The plume's location varies seasonally with discharge, prevailing near-shore winds, and ocean currents. In summer, the plume extends far to the south and offshore along the Oregon coast. During the winter, it shifts northward and inshore along the Washington coast. Strong density gradients between ocean and plume waters create stable habitat features where organic matter and organisms are concentrated (Fresh et al. 2005). The Columbia River plume can extend beyond Cape Mendocino, California, and influences salinity in marine waters as far away as San Francisco (Northwest Power and Conservation Council 2000). For the purposes of this estuary recovery plan module, the plume is considered to be off the immediate coasts of both Oregon and Washington and to extend outward to the continental shelf.

Major Land Uses

A variety of land uses are found adjacent to the Columbia River estuary. The area contains multiple cities and political jurisdictions, including Portland, which is Oregon's largest city, and Vancouver, the fourth largest Washington city. Smaller cities include Astoria,

Cathlamet, Longview, Kalama, Woodland, and Camas. Approximately 2.5 million people live in the vicinity of the estuary, and more are coming. Five deep-water ports in the area support a shipping industry that transports 30 million tons of goods annually (Lower Columbia Fish Recovery Board 2004), worth $13 billion each year (Columbia River Channel Improvement Reconsultation Project). Timber harvest occurs throughout the basin—six major pulp mills contribute to the region's economy. Until the early 2000s, aluminum plants along the river produced more than 40 percent of the country's aluminum. Agriculture is widespread throughout the floodplain and includes fruit and vegetable crops along with beef and dairy cattle. Commercial and recreational fishing activity plays an important role in local economies, bringing in millions of dollars of revenue each year. Primary outdoor recreational activities include fishing, wildlife observation, hunting, boating, hiking, and windsurfing.

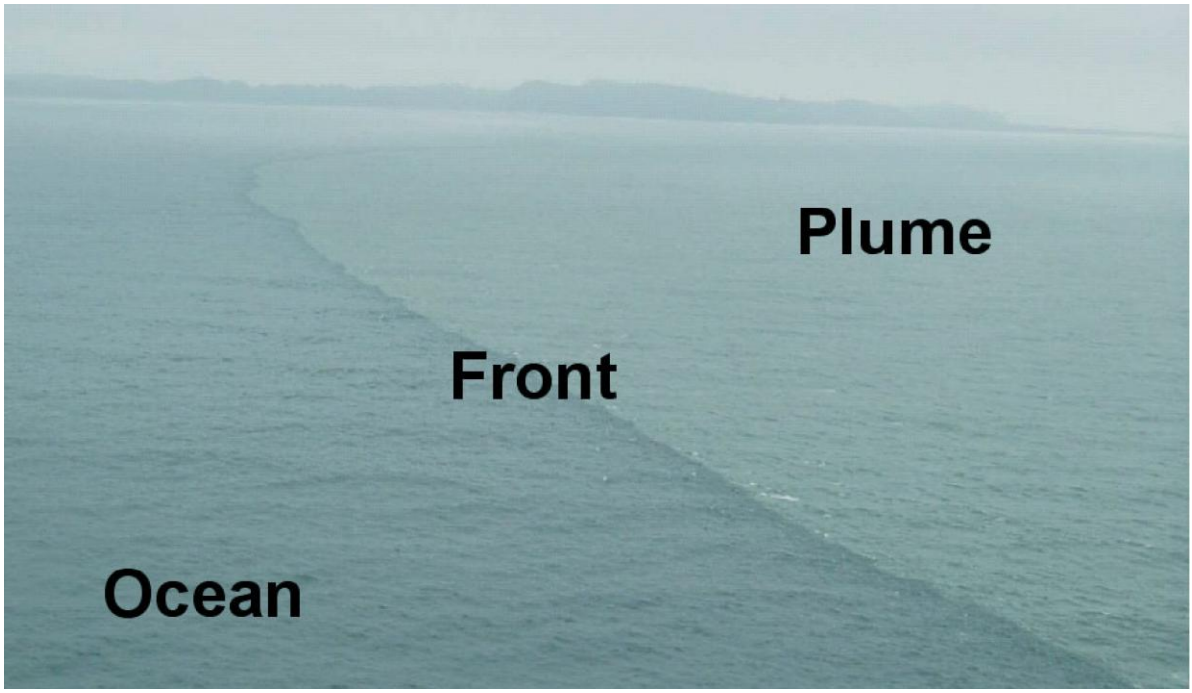


FIGURE 1-3
Plume Front
(Photo courtesy of NMFS.)

Two Centuries of Change

Before Euro-American settlement of the Pacific Northwest, the Columbia River estuary and plume served as a physical and biological engine for salmon. Juveniles from hundreds of populations of steelhead, chum, Chinook, and coho entered the estuary and plume every month of the year, with their timing honed over evolutionary history to make use of habitats rich with food. A beach seine survey during any month of the year would likely have yielded salmon of all species and many populations, with individuals of many sizes. This genetic variation in behavior was an important trait that allowed salmon and steelhead

to occupy many habitat niches in time and space. It also guarded populations against catastrophic events such as volcanic eruptions (Bottom et al. 2005).

Today the Columbia River estuary and plume are much different. Notably, the North and South jetties at the mouth of the river restrict the marine flow of nutrients into the estuary. Dikes and levees lining the Washington and Oregon shores prevent access to areas that once were wetlands. New islands have been formed by dredged materials, and pile dike fields reach across the river, redirecting flows. Less visible but arguably equally important are changes in the size, timing, and magnitude of flows that, 200 years ago, regularly allowed the river to top its banks and provide salmon and steelhead with important access to habitats and food sources. Flow factors, along with ocean tides, are key determinants of habitat opportunity and capacity in the estuary and plume.

Salmon have thrived in the Columbia River for up to 1 million years (Lichatowich 1999). In the last 100 years, the entire Columbia River has undergone tremendous change as a direct result of people living and working in the basin. While the threats to salmon persistence are very diverse, at some level it is the increase in human population in the Northwest that underlies every human threat. There are an estimated 5 million people in the Columbia River basin today, and somewhere between 40 million and 100 million people are predicted to be living in the basin by the end of the twenty-first century (National Research Council 2004). If we want healthy salmon runs at the same time that our population is multiplying, our interactions with land and water must pose fewer threats to salmonids than they have in the last 100 years. Before identifying management actions that could do just that, this document discusses which salmonids currently use the Columbia River basin, and how.

CHAPTER 2

Salmonid Use of the Estuary and Plume

The estuary and plume provide salmonids with a food-rich environment where they can undergo the physiological changes needed to make the transition from freshwater to saltwater habitats, and vice versa. Every anadromous salmonid that spawns in the Columbia River basin undergoes such a transformation twice in its lifetime—the first time during its first year of life (or soon after) when migrating out to sea, and the second time 1 to 3 years later, as an adult returning to spawn. The transition zone where juvenile salmonids undergo this transformation is thought to extend from the estuary itself to the near-shore ocean and plume habitats and into rich upwelling areas near the continental shelf (Casillas 1999).

The estuary and plume also serve as rich feeding grounds where juveniles have the opportunity for significant growth as they make the important transition from freshwater to seawater. Studies have shown that juvenile salmon released within the estuary and plume returned as larger adults and in greater numbers than juveniles released outside the transition zone (Emmett and Schiewe 1997 as cited in Casillas 1999). Thus, although juvenile salmonids face risks from a variety of threats in the estuary and plume (see Chapter 4), these environments can be highly beneficial. In the salmon life cycle, successful estuarine and plume residency by juveniles is critical for fast growth and the transition to a saltwater environment.

Clearly, the Columbia River estuary and plume are uniquely important to salmonids, and conditions in the estuary and plume undoubtedly affect salmonid survival. Yet the estuary and plume represent just one in a series of ecosystems that salmon use in their complex life cycle. Exploring the connections among these ecosystems, the habitats they provide, the salmonid species that use them, and the variety of life histories those salmonids display sheds further light on the role of the estuary and plume in the salmonid life cycle.

Salmonid Species in the Columbia River Basin

Before Euro-American settlement, the Columbia River basin was used extensively by six species of the family Salmonidae and the genus *Oncorhynchus*: Chinook, chum, coho, and sockeye salmon plus two trout species: steelhead and sea-run cutthroat (Lichatowich 1999). Within these six species, 13 ESUs,[1] representing more than 150 populations of salmon and steelhead, have been listed as threatened or endangered under the Federal Endangered Species Act (Bottom et al. 2005). All 13 of the ESUs use the estuary and plume as an essential link in their far-reaching life cycles.

[1] NMFS has revised its species determinations for West Coast steelhead under the Endangered Species Act (ESA), delineating steelhead-only "distinct population segments" (DPSs). The former steelhead ESUs included both anadromous steelhead trout and resident, non-anadromous rainbow trout, but NMFS listed only the anadromous steelhead. The steelhead DPS does not include rainbow trout, which are under the jurisdiction of the U.S. Fish and Wildlife Service. In January 2006, NMFS listed five Columbia River basin steelhead DPSs as threatened (71 FR 834). To avoid confusion, references to ESUs in this estuary recovery plan module imply the steelhead DPSs as well.

It is estimated that historically up to 16 million salmon from perhaps hundreds of distinct populations returned to the Columbia River each year (Lichatowich 1999). This contrasts markedly with recent returns of salmon and steelhead adults, which have averaged about 1.7 million, with 65 to 75 percent of those fish being of hatchery origin.[2] For 2006, scientists from the NMFS Northwest Fisheries Science Center estimated that about 168 million juveniles would enter the estuary (Ferguson 2006b).[3] This suggests that only 1 percent of the juveniles entering the estuary will return as adults and 99 percent are lost as a result of all the limiting factors (human and natural) in the estuary, plume, nearshore, and ocean.

Life History Types and Strategies

In discussing salmonids, fish scientists commonly refer to ocean type and stream type to distinguish two main freshwater rearing strategies. Ocean-type salmonids are characterized by migration to sea early in their first year of life, after spending only a short period in freshwater (Fresh et al. 2005). Ocean types may rear in the estuary for weeks or months, making extensive use of shallow, vegetated habitats such as marshes and swamps, where significant changes in flow and habitat have occurred (Fresh et al. 2005). Conversely, stream-type salmonids are characterized by migration to sea after rearing for more extended periods in freshwater, usually at least 1 year (Fresh et al. 2005). Table 2-1 shows the general characteristics of ocean-type and stream-type ESUs.

TABLE 2-1
Characteristics of Ocean- and Stream-Type Salmonids

Attribute	Ocean-Type Fish: fall Chinook, chum	Stream-Type Fish: coho, spring Chinook, steelhead
Residency time	Short freshwater residence Longer estuarine residence Longer ocean residence	Long freshwater residence (>1 year) Shorter estuarine residence Shorter ocean residence
Size at estuary entry	Smaller	Larger
Primary habitat use	Shallow-water estuarine habitats, especially vegetated ones	Deeper, main-channel estuarine habitats; use plume more extensively

Adapted from Fresh et al. 2005.

In the Columbia River estuary, both ocean- and stream-type salmonids experience significant mortality. However, because the two types typically spend different amounts of time in the estuary and plume environments and use different habitats, they are subject to somewhat different combinations of threats and opportunities.

For ocean-type juveniles, mortality is believed to be related most closely to lack of habitat, changes in food availability, and the presence of contaminants, including persistent, bioaccumulative contaminants present in sediments in the shallow-water habitats where ocean-type juveniles rear in the estuary. Stream types are affected by these same factors, although presumably to a lesser degree because of their shorter residency times in the

[2] This is an informal estimate; determining the ratio of hatchery-origin fish with more certainty would require stock-by-stock run calculations averaged over many years.

[3] 2006 was a normative year and is considered representative.

estuary. However, stream types are particularly vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid channel areas located near habitat preferred by piscivorous birds (Fresh et al. 2005), and they are subject to pinniped predation when they return to the estuary as adults (see Chapter 3). Also, scientists at the NMFS Northwest Fisheries Science Center now hypothesize that larger numbers of stream-type yearling juveniles are susceptible to predation by northern pikeminnow than was previously thought; this predation occurs as the juveniles move into the shallows behind structures such as pilings or pile dikes to forage (Casillas 2007); this and related hypotheses are in the process of being tested through a program initiated by the Federal action agencies (the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and Bonneville Power Administration) and the Lower Columbia River Estuary Partnership. Additionally, stream-type salmonids are thought to use the low-salinity gradients of the plume to achieve growth and gradually acclimate to saltwater. Changes in flow and sediment delivery in the plume may affect stream-type juveniles in a way similar to how estuary conditions affect ocean-type juveniles; however, additional research is needed to determine more precisely how stream types use the plume (Casillas 2006).

Fish scientists also describe salmonids in terms of the life history strategies they employ, meaning a population's unique pattern of preferred spawning substrate, habitat use, migration timing, length of estuarine and marine residency, and so on. For thousands of years, Columbia River salmonids exhibited great diversity in life history strategies, exploiting a wide array of the habitat niches available to them. This rich diversity in life history strategies allowed salmonids to persist as species for millennia even when individual populations were wiped out by disease or natural disturbances such as volcanic eruptions.

Table 2-2 identifies the six basic life history strategies used by salmon and steelhead in the Columbia River and their general attributes.

Changes in Life History Diversity

The 13 listed ESUs in the Columbia River express much less diversity in life history strategies now than they did historically. Formerly, both ocean- and stream-type salmonids entered the estuary and plume throughout the year, at a great variety of sizes, which reflected the various life history strategies in Table 2-2. Today juveniles tend to arrive in pulses and are more uniform in size.

Table 2-3 shows losses in life history diversity in the Columbia River. The table identifies the dominant life history type (ocean vs. stream) and strategies for each ESU, the prevalence of each life history strategy, and whether that prevalence has changed from historical times to the present. The number of life history strategies employed by some ESUs, such as Columbia River chum, have not changed. But for other ESUs—notably the Lower Columbia River coho—several life history strategies that used to exist have been lost. In a research project studying outmigration of juvenile Chinook salmon in the lower Willamette River, results indicated the presence of fry and fingerling juveniles in all months of the year. Although the specific ESUs of these juvenile salmon have not been confirmed, the results indicate more contemporary life history stages present than indicated in Table 2-3 (Friesen et al. 2007).

Losses in life history diversity can also be seen in Figure 2-1, which compares historical and current estuarine life history types for one brood year of Chinook salmon. The figure shows a reduction in the number of strategies available in the contemporary versus historical estimates.

Some of the losses in salmonid life history diversity are attributable to habitat alterations throughout the Columbia River basin that have eliminated entire populations of salmon and steelhead. In other cases, hatcheries and harvest impacts have reduced the health and genetic makeup of species. As a result, many of the populations currently using the estuary and plume are significantly different than the fish that historically used the various habitats available to them, and some existing habitats may not be being used by salmonids at all.

TABLE 2-2
Life History Strategies and Their Attributes

Life History Strategy	Attributes
Early fry	Freshwater rearing: 0 - 60 days Size at estuarine entry: <50 mm Time of estuarine entry: March - April Estuarine residence time: 0 - 40 days
Late fry	Freshwater rearing: 20 - 60 days Size at estuarine entry: <60 mm Time of estuarine entry: May - June, present through Sept. Estuarine residence time: <50 days
Early fingerling	Freshwater rearing: 60 - 120 days Size at estuarine entry: 60 - 100 mm Time of estuarine entry: April - May Estuarine residence time: <50 days
Late fingerling	Freshwater rearing: 50 - 180 days Size at estuarine entry: 60 - 130 mm Time of estuarine entry: June - October, present through winter Estuarine residence time: 0 - 80 days
Subyearling (smolt)	Freshwater rearing: 20 - 180 days Size at estuarine entry: 70 - 130 mm Time of estuarine entry: April - October Estuarine residence time: <20 days
Yearling	Freshwater rearing: >1 year Size at estuarine entry: >100 mm Time of estuarine entry: February - May Estuarine residence time: <20 days

Adapted from Fresh et al. 2005.

TABLE 2-3
Linkage between Salmonid ESU, Dominant Life History Type, and Life History Strategy in the Columbia River Estuary

ESU	Life History Type	Historical and Current Life History Strategies					
		Early Fry	Late Fry	Early Fingerling	Late Fingerling	Sub-yearling	Yearling
Columbia River chum salmon	Ocean	Abundant	Abundant	—	—	—	—
Snake River sockeye salmon	Stream	—	—	—	—	Rare	Abundant
Lower Columbia River coho salmon	Stream	Historically rare, currently absent	Historically rare, currently absent	Historically rare, currently absent	Historically rare, currently absent	Rare	Abundant
Upper Columbia River steelhead	Stream	—	—	—	—	Historically rare, currently absent	Abundant
Snake River steelhead	Stream	—	—	—	—	Historically rare, currently absent	Abundant
Lower Columbia River steelhead	Stream	—	—	—	Historically rare, currently absent	Historically medium, currently rare	Abundant
Middle Columbia River steelhead	Stream	—	—	Historically rare, currently absent	Historically rare, currently absent	Historically medium, currently rare	Abundant
Upper Willamette River steelhead	Stream	—	—	—	—	Historically rare, currently absent	Abundant
Snake River fall Chinook salmon	Ocean	—	—	Historically medium, currently rare	Historically medium, currently rare	Abundant	Historically rare, currently medium
Upper Willamette River Chinook salmon	Ocean	Historically rare, currently absent	Historically rare, currently absent	Historically medium, currently rare	Historically medium, currently rare	Historically rare, currently medium	Abundant
Lower Columbia River Chinook salmon	Ocean	Historically medium, currently rare	Historically medium, currently rare	Historically medium, currently rare	Historically medium, currently rare	Historically medium, currently abundant	Rare
Upper Columbia River spring Chinook salmon	Stream	—	—	Historically rare, currently absent	Historically rare, currently absent	Rare	Abundant
Snake River spring/summer Chinook salmon	Stream	—	—	Historically rare, currently absent	Historically rare, currently absent	Rare	Abundant

"—" = historically and currently absent.
Adapted from Fresh et al. 2005.

Relationship of the Estuary to the Columbia River Basin

In 2005, scientists working at the NMFS Northwest Fisheries Science Center published a technical memorandum that establishes an ecologically based conceptual framework for understanding the estuary within the larger context of the Columbia River basin. In *Salmon*

at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon, Bottom et al. (2005) hypothesize that Columbia River salmon's resilience to natural environmental variability is embodied in population and life history diversity, which maximizes the ability of populations to exploit available estuarine rearing habitats. Bottom et al.'s conceptual framework is based on Sinclair's (1988) member/vagrant theory, which proposes general principles for understanding marine species with complex life cycles. The member/vagrant theory serves as a useful tool for evaluating salmon's specific needs in estuaries in relation to the entire continuum of their habitat needs throughout their complex life cycles (Bottom et al. 2005).

Bottom et al. (2005) hypothesize that how an individual salmon or steelhead uses the ecosystems it encounters—when juveniles migrate, how big they are, what habitats they use, and how long they stay in a particular habitat—correlates directly to the discrete population of fish that individual is part of. In other words, different populations within ESUs employ different life history strategies. For example, two populations of steelhead within an ESU may produce juveniles of different sizes that enter the estuary at different times, and these juveniles may use distinct habitats that may be available only at that particular time.

Considering that the estuary is just one of three major ecosystems used by salmon and steelhead, the member/vagrant theory implies that how juveniles migrate and use estuarine habitat may depend as much on the status of upriver habitats and corresponding populations as on environmental conditions in the estuary itself (Bottom et al. 2005). In other words, if there is a close relationship between particular geographical features in the estuary and the life history of a discrete salmonid population, use of the estuary may reflect the abundance and life history strategy of the associated population, which is in part a function of upstream conditions. Thus, if salmonid migration and rearing behaviors in the estuary are linked to specific geographic features and those features are reduced or eliminated, mortality in the population that uses those features increases (Bottom et al. 2005). By the same token, if salmonid populations are lost because of other factors (such as blockage by dams), habitats in the estuary may be left unoccupied.

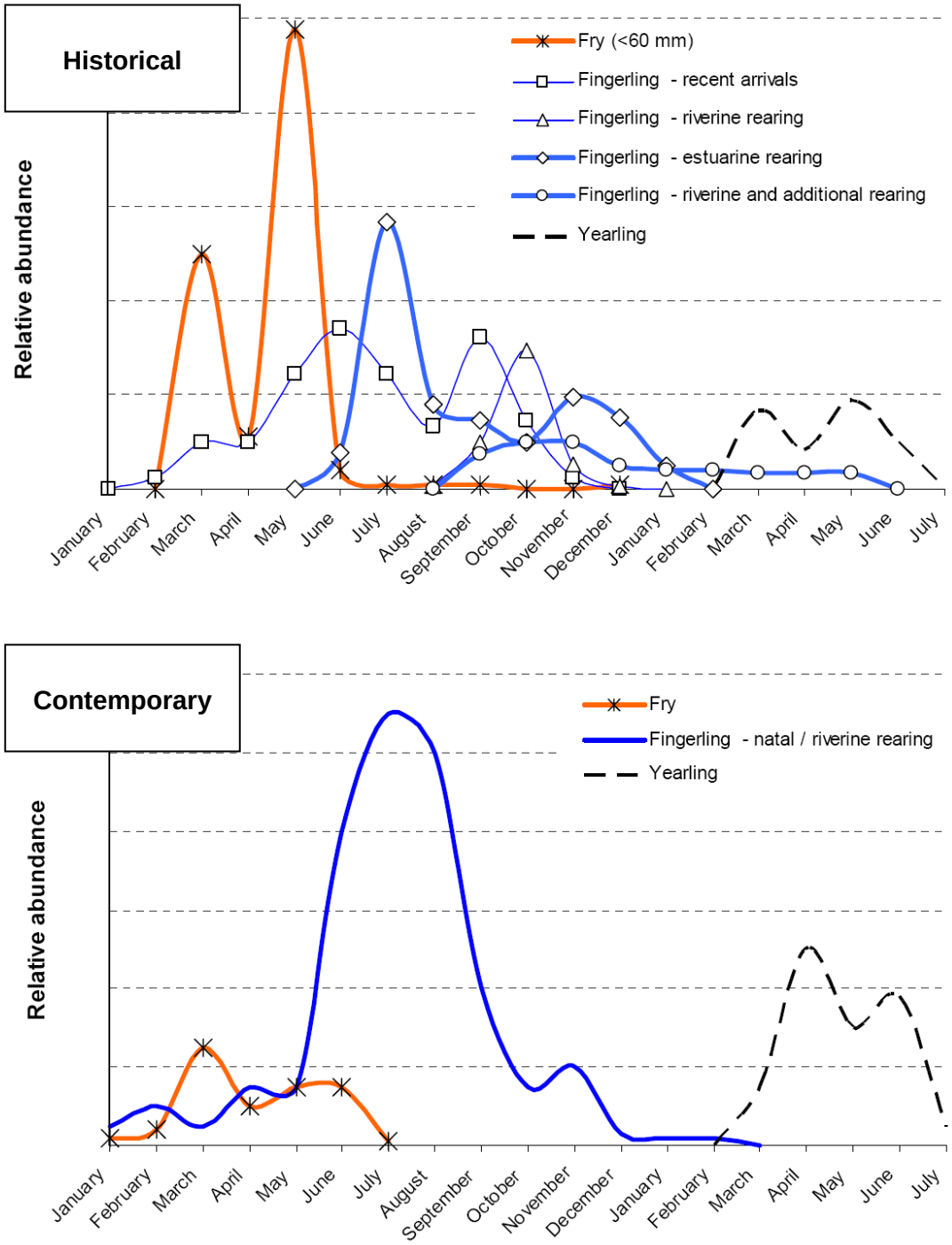


FIGURE 2-1
Historical and Contemporary Early Life History Types of Chinook Salmon in the Columbia River Estuary
(Reprinted from Fresh et al. 2005.)

The implication for salmon recovery in the Columbia River basin is that habitat use by salmonids must be considered from a multi-ecosystem perspective if we are to understand which components of each ecosystem—tributaries, mainstem, estuary, plume, nearshore, and ocean—are limiting the overall performance of salmon.

Summary

Since 1991, 13 Columbia River ESUs have been listed as threatened or endangered under the Federal Endangered Species Act. During their complex life cycles, salmon and steelhead rely on many diverse ecosystems, from tributaries to ocean environments, that span hundreds or thousands of miles. For recovery efforts to be successful, it is necessary to understand salmonids' requirements during all stages of their life cycles. Thus, although the estuary and plume represent important stages in the salmonid life cycle, these ecosystems must be considered within the context of other life cycle stages if management actions are to be effective. Perhaps most central to the recovery of listed ESUs is the importance of conserving biological diversity and the native ecosystems it depends on (Bottom et al. 2005).

CHAPTER 3

Limiting Factors

Chapter 3 identifies and prioritizes the key habitat-related physical, chemical, or biological features that scientific literature and area experts suggest are affecting the viability of ESUs and their component populations in the estuary. These features are referred to as limiting factors.[1] The discussion of limiting factors in this chapter pertains to the estuary and plume; however, upstream limiting factors in some cases have a direct bearing on conditions in the estuary. Discussion of limiting factors in this chapter generally relates to specific factors that limit salmonid productivity; however, it is recognized that the effects of multiple limiting factors may have a compounding effect. The estuary module does not address this compounding effect because of a lack of technical information to address the topic.

Determining Estuary Habitat Limiting Factors

Sources

It would be desirable to know with certainty which factors are responsible for the highest losses of salmon and steelhead in the estuary so that recovery actions could be focused on activities to address those factors. But as described below, researchers have quantified salmonid mortality in the estuary for only a few limiting factors, and additional research on mortality is needed to understand which factor (or factors) is most limiting salmonid viability in the estuary. In the absence of more comprehensive mortality data, the estuary recovery module relies on expert opinion and available information in the literature to identify and prioritize limiting factors.

PC Trask & Associates, Inc., based this chapter on a thorough review and synthesis of pertinent literature, supplemented by input from staff at the NMFS Northwest Fisheries Science Center and Northwest Regional Office, the Lower Columbia River Estuary Partnership, and the Lower Columbia Fish Recovery Board. The following documents, among others, provided consistent guidance:

- *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon* (Bottom et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center
- *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability* (Fresh et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center
- "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" and its supplement—Northwest Power and Conservation Council (2004)

These three literature sources, and others, identified and evaluated limiting factors in a similar manner. But it should be noted that the three sources have separate goals, and this

[1] In this module, the term "limiting factors" is used to indicate the full range of factors that are believed to be affecting the viability of salmon and steelhead in the estuary and not to indicate the single factor that is most limiting.

affects each document's structure and content. Thus, the depth and breadth of information were not always consistent across documents. To develop a relatively comprehensive list of factors that are limiting ESUs' viability in the estuary and to weigh the probable effect of each factor, the author had to synthesize information from multiple sources.

Mortality Estimates

Estimates of salmon and steelhead mortality in the estuary and mainstem are not well supported in the literature, especially in the case of indirect mortality. (There are more reliable estimates of direct impacts to salmonids populations than indirect or combined impacts.) However, some modeling efforts have made assumptions about estuary mortality. One example is Ecosystem Diagnosis and Treatment (EDT), a life-cycle model that accounts for the estuarine stage of salmon and steelhead in tributaries of the Columbia River. For lower Columbia River ESUs, EDT assumes 18 to 58 percent mortality for various populations.

In addition, research is under way by NMFS, the U.S. Army Corps of Engineers, and Battelle Laboratories to estimate the survival rate of juvenile salmonids in the lower Columbia River. This research involves technologies for miniaturizing acoustic tags to a size capable of tracking yearling and subyearling juveniles. Current technology developed for the project allows for the tracking of subyearlings of sizes down to approximately 90 mm. Data from 2005 indicated an approximate range of survival of 65 to 75 percent for subyearlings and yearlings during their residency in the estuary (Ferguson 2006a).[2] It is probable that actual survival rates are lower than these estimates suggest because the research did not address mortality among juveniles smaller than 90 mm, mortality occurring in the plume and nearshore, or delayed mortality.

There are reliable mortality estimates for a few limiting factors. For example, Caspian tern predation was estimated to be responsible for the mortality of about 5.5 million smolts in 2007 (Roby et al. 2008)—up to 14.1 percent of in-river migrant steelhead smolts and 7.7 percent of transported steelhead smolts (Roby et al. 2008). Double-crested cormorants appear to be consuming approximately 6 percent of steelhead, 6 percent of subyearling Chinook, 2 percent of yearling Chinook, and 1 percent of sockeye salmon entering the estuary (Fredricks 2010).

Other limiting factors, such as pinnipeds (primarily affecting adult survival), ship wake stranding, and toxic contaminants, have incomplete mortality estimates associated with them. Toxic contaminants, for instance, can have lethal and sublethal impacts to salmonids, resulting in direct and indirect mortality, both of which are difficult to quantify. In most cases it is very difficult to point to a specific limiting factor and then estimate mortality. This is because of the inherent complexity associated with connecting the physical, chemical, and biological features that limit the productivity of salmon and steelhead.

[2] The mean yearling survival estimate for the years 2005 to 2009 is 75.8 percent (standard deviation = 5.4 percent), while the mean subyearling survival estimate for the same period is 67.6 percent (standard deviation = 9.0 percent) (Casillas 2010). Because these more current survival estimates are very close to the estimates used when the module was initially drafted, and because local recovery planners in the Washington and Oregon Lower Columbia region incorporated the 2005 estimates into their salmon recovery plans, the module was not updated with the most current numbers. In future revisions of the module and the Lower Columbia tributary plans, needed updates will be made.

Density-Dependent Mortality

In the Columbia River estuary, limiting factors such as off-channel habitat availability, competition with native and exotic fish for food and space, disease, and predation by piscivorous fish and native birds may in part be manifestations of density dependence. Density dependence refers to changes in the size of a population that are themselves a result of the size of the population, such as when a population declines because it has exceeded the amount of resources available to support it. Density-dependent mortality can occur through several mechanisms, such as direct competition for limited food and habitat and changes in the foraging activity of predators. With salmon and steelhead, density-dependent mortality can occur at any stage in the animal's life cycle and may be exacerbated by the introduction of large numbers of hatchery fish released over a relatively short period of time, or by the cumulative effects of such releases on natural-origin salmon.[3]

How much density-dependent mortality is taking place in the estuary compared to in the ocean is unclear. There is some evidence that density-dependent mortality is occurring in the open ocean. For example, during years when salmon are especially numerous in the ocean, their growth rates are reduced (Peterman 1984 as cited in Ford 2007). One study found that, during years when nearshore ocean productivity was low, survival of wild Snake River Chinook decreased as releases of hatchery Chinook increased (Levin et al. 2001 as cited in Ford 2007). However, another study found no connection between ocean conditions and density-dependent mortality, which appeared to be occurring among wild Snake River Chinook as hatchery steelhead were released (Levin and Williams 2002 as cited in Ford 2007). The authors suggested that the apparent density-dependent mortality could be better explained by interactions in the tributaries or estuary than by interactions in the ocean.

There is growing awareness among scientists studying the Columbia River estuary that mechanisms related to density dependence may limit salmon and steelhead while they are using estuary and plume habitats. Scientists studying Skagit River fall Chinook have documented density dependence-related mortality as a result of loss of habitat in the Skagit estuary and believe that such mortality can be attributed to a 75 percent loss of tidal delta estuarine habitat (Beamer et al. 2005). With similar habitat losses in the Columbia River estuary, it is possible that too many fish are competing for limited habitat and associated resources in the estuary at key times, and that the resulting stressors translate into reduced salmonid survival. The NMFS Northwest Fisheries Science Center currently is investigating potential density-dependent mortality in the estuary. The "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" raised the specter of density dependence in the estuary and recommended continued research to analyze conditions there (Northwest Power and Conservation Council 2004). Thus, although the occurrence of density dependence-related mortality in the Columbia River estuary has not been proven, given the dramatic changes in habitat opportunity and capacity in the estuary over the last 200 years, it is likely that some of the mortality associated with the limiting factors described in this chapter is related to increased density of juveniles in the estuary.

[3] It is also possible that inverse density dependence processes occur in some situations. For example, large numbers of adult salmon could swamp marine mammal predators at Bonneville Dam, and the adult survival rates could be higher than in scenarios with smaller numbers of adult fish.

Consistent with this concern, the NMFS Northwest Region Salmon Recovery Division and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats. Needs include an assessment of the state of the science to help identify priority research on the ecological interactions between hatchery-origin and natural-origin salmon in these habitats and to better define the ecological risks of such interactions. A conference on ecological interactions between hatchery-origin and natural-origin salmon held in May 2010 in Portland, Oregon, contributed to describing the state of the science on these interactions. Conference proceedings will be published and priority research needs identified. Follow-up workshops will help refine the assessment, develop specific research plans, and identify funding sources.

The estuary recovery plan module assumes that density-dependent mortality that may be occurring in the estuary is manifested in part through limiting factors related to habitat availability, competition for food and space, disease, and predation. Given the uncertainty about the mechanisms and effects of density dependence in the estuary, density dependence itself is not included as a limiting factor in the module. Neither are the effects of hatchery fish. Although it is likely that hatchery fish influence the estuarine survival of naturally produced fish (possibly through mechanisms of competition, predation, and disease transfer), the focus of this estuary recovery plan module is the effects of habitat conditions and processes in the estuary and plume, rather than the effects of hatchery or harvest practices. But the degree of density-dependent mortality occurring in the estuary, the role of large releases of hatchery fish, and the cumulative impact of hatchery releases on density-dependent mechanisms are worth exploring through further research.

Habitat-Related Limiting Factors

Salmonid populations exhibit diverse strategies that guide them through various habitats and ecosystems in specific sequences and patterns. If those sequences and patterns are interrupted, increased mortality may result. Thus, mismatches between the needs of salmonid populations and the availability of habitats to meet those needs can limit salmonid performance in the estuary and plume. The member/vagrant theory discussed in Chapter 2 underscores the need to consider relationships between ESUs' life history strategies and the quality, quantity, and availability of habitats in the estuary and other ecosystems that are interconnected via the salmon and steelhead's complex life cycle.

The habitats that salmonids occupy during their residency in the estuary and plume are formed through the interaction of ocean forces, land, and river flow (Fresh et al. 2005). Flows entering the estuary govern the general availability of habitats, along with sediment transport, salinity gradients, and turbidity, which are themselves aspects of habitat or habitat formation. Over the last 200 years, the magnitude, timing, and frequency of flows have changed significantly, with corresponding effects on the formation and availability of salmonid habitats. Some habitat has been removed, which has reduced the total acreage of the estuary by approximately 15 percent (Fresh et al. 2005). In other cases, particular habitat types have been transformed into other habitat types, and the resulting mosaic of habitats may not be meeting the needs of salmonids as well as the historical pattern of habitats did. For example, approximately 77 percent of historical tidal swamp has been lost (Northwest

Power and Conservation Council 2004), while other shallow-water habitats have increased significantly. The loss of tidal swamps and other forested or vegetated wetlands represents a loss of habitat that ocean-type salmonids use during their estuarine residence. In short, habitat opportunity and capacity have been degraded in the estuary and plume, and alterations in flow have contributed significantly to losses in in-channel, off-channel, and plume habitat. An accurate accounting of specific habitat type changes from pre-European settlement to the present day has not been initiated estuarywide. This measurement of change is important to guiding restoration priorities and represents a significant data gap in the estuary.

An important goal of this estuary recovery module is to describe the various habitats and limiting factors that both ocean- and stream-type juvenile salmonids encounter in the Columbia River estuary and plume. However, current scientific understanding of how stream-type juveniles use the various habitats they encounter in the estuary and plume is less robust than what is known about ocean types' habitat use. To fill this important knowledge gap, the NMFS Northwest Fisheries Science Center and others are exploring how stream-type juveniles expressing all the different possible life history strategies use individual estuarine habitats.

Affected salmonids: Because of their longer estuary residence times and tendency to use shallow-water habitats, ocean-type ESUs are more affected by flow alterations that structure habitat and/or provide access to wetland or floodplain areas than are stream-type ESUs. Stream types have relatively short estuary residence times and use the plume much more extensively than ocean types do. Thus stream-type salmonids are affected by habitat elements such as the shape, behavior, size, and composition of the plume (Fresh et al. 2005).

Reduced In-Channel Habitat Opportunity

In-channel habitat opportunity in the estuary is a function of the size of river flows, the timing of river flows, incoming and outgoing tides, and the amount and patterns of sediment accretion. Together, tidal action, river flow, and sediment movement create a constantly changing mosaic of channel habitats as water levels rise and fall, sands shift, and salinity gradients move in response to tides. To support salmonids, the various habitats in the estuary need to be connected both spatially and in time. With twice-daily tidal fluctuations, areas that are accessible at one point during the day can be inaccessible 6 hours later or can trap salmonids, exposing them to higher water temperatures and lower dissolved oxygen levels that can result in stress or mortality. Changes in both flow and sediment transport have reduced in-channel habitat opportunity.

Limiting Factor: Flow-Related Estuary Habitat Changes. The ability of juvenile salmon to access and benefit from habitat depends greatly on instream flow (Fresh et al. 2005). Changes in the quantity and seasonality of flows in the estuary have a direct bearing on whether key habitats are available to salmonids, when and how long those habitats are available, and whether and how they connect with other key habitats. In addition, juvenile salmonids have physiological or behavioral traits that set the timing for their transformation to saltwater, and changes in flows may interrupt this timing.

Both the quantity and timing of instream flows entering the Columbia River estuary and plume have changed from historical conditions (Fresh et al. 2005). Jay and Naik (2002)

reported a 16 percent reduction of annual mean flow from 1878 to the present and a 44 percent reduction in spring freshet flows. Jay and Naik also reported a shift in flow patterns in the Columbia to 14 to 30 days earlier in the year, meaning that spring freshets are occurring earlier in the season.[4] In addition, the interception and use of spring freshets (for irrigation, reservoir storage, etc.) have caused increased flows during other seasons (Fresh et al. 2005). These changes in the volume and timing of Columbia River flow are limiting factors for salmon and steelhead and have affected habitat opportunity and capacity in the estuary and plume. It is likely that global climate change will contribute to further flow-related changes in estuary habitat. However, changes in flow entering the estuary as a result of climate change are expected to be less than those caused by construction of the hydrosystem (Independent Scientific Advisory Board 2007).

Limiting Factor: Sediment/Nutrient-Related Estuary Habitat Changes. The transport of sediment is fundamental to habitat-forming processes in the estuary through sediment deposition and erosion (Fresh et al. 2005). An estuary's form is altered primarily through the deposition of sediment—either sediment that is reworked from other parts of the estuary or sediment that enters the estuary from the watersheds or ocean. Sediment moves among each of the components within the estuary, allowing the estuary as a whole to continually be adjusting toward some long-term equilibrium form in response to changes in physical or geomorphic processes (Philip Williams & Associates and Farber 2004). Sediment from the estuary and upstream sources also affects the formation of nearshore ocean habitats north and south of the Columbia River entrance.

Since the late nineteenth century, sediment transport from the interior basin to the Columbia River estuary has decreased about 60 percent and total sediment transport has decreased about 70 percent (Jay and Kukulka 2003). This reduction in the amount of sediment transport in the Columbia River has affected habitat-forming processes in the estuary and plume (Bottom et al. 2005) and is presumed to be a limiting factor for salmon and steelhead because it limits the accretion of sediment and thus the formation of shallow-water habitats. Although the consequences of the reduced transport of sediment through the estuary and plume are not fully understood, the magnitude of change is very large compared to historical benchmarks (Fresh et al. 2005).

Sediment also provides important nutrients that support food production in the estuary and plume. Microdetrital food particles adhere to sediment suspended in the water column, making different food sources available to different species than was the case historically. Currently, organic matter associated with fine sediments supplies the majority of estuarine secondary productivity in the food web (Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004).

Reduced Off-Channel Habitat Opportunity

Columbia River access to its historical floodplain is an important factor for rearing ocean-type juvenile salmonids. Stream-type juvenile salmonids also are believed to benefit from access to off-channel habitats, which support less dominant stream-type life histories and provide food resources for stream types during downstream migration (Bottom et al. 2005).

[4] These analysis were calculated by comparing observed flow (data from a gauge), estimated adjusted flow (observed flow corrected for reservoir manipulations), and estimated virgin flow (estimate of river flow without human alteration).

Historically, flows that topped the river's bank provided juvenile salmonids with access to low-velocity areas in the lower river and estuary that juveniles used as refugia and for rearing; many of these areas were dominated by Sitka spruce tidal swamps, which were an integral component of the estuarine ecosystem. Overbank flows contributed key food web inputs to the ecosystem and influenced wood recruitment, predation, and competition in the estuary (Fresh et al. 2005).

Today, mainstem habitat in the Columbia and Willamette rivers has, in many cases, been reduced to a single channel (Northwest Power and Conservation Council 2004), and channelization of the estuary has eliminated access to an estimated 77 percent of historical tidal swamps (Fresh et al. 2005). In fact, over the past 200 years the surface area of the estuary has decreased by approximately 20 percent (Fresh et al. 2005).

The near elimination of overbank flooding is a function of both reductions in peak freshet flows (as a result of flow regulation for electricity generation, storage for irrigation and municipal use, and flood control) and increases in the bankfull level of the Columbia River (as a result of dikes and levees), among other factors.

Figure 3-1 shows diked areas from the estuary mouth to Bonneville dam. This map was generated from a GIS database developed by the University of Washington, U.S. Geological Survey, and Lower Columbia River Estuary Partnership that provides statistics and maps depicting the historical floodplain, diked areas, dredged material disposal sites, over-water structures, contaminant monitoring sites, and other key features in the estuary. Some of these features are shown in GIS-based reach maps presented in Appendix A.

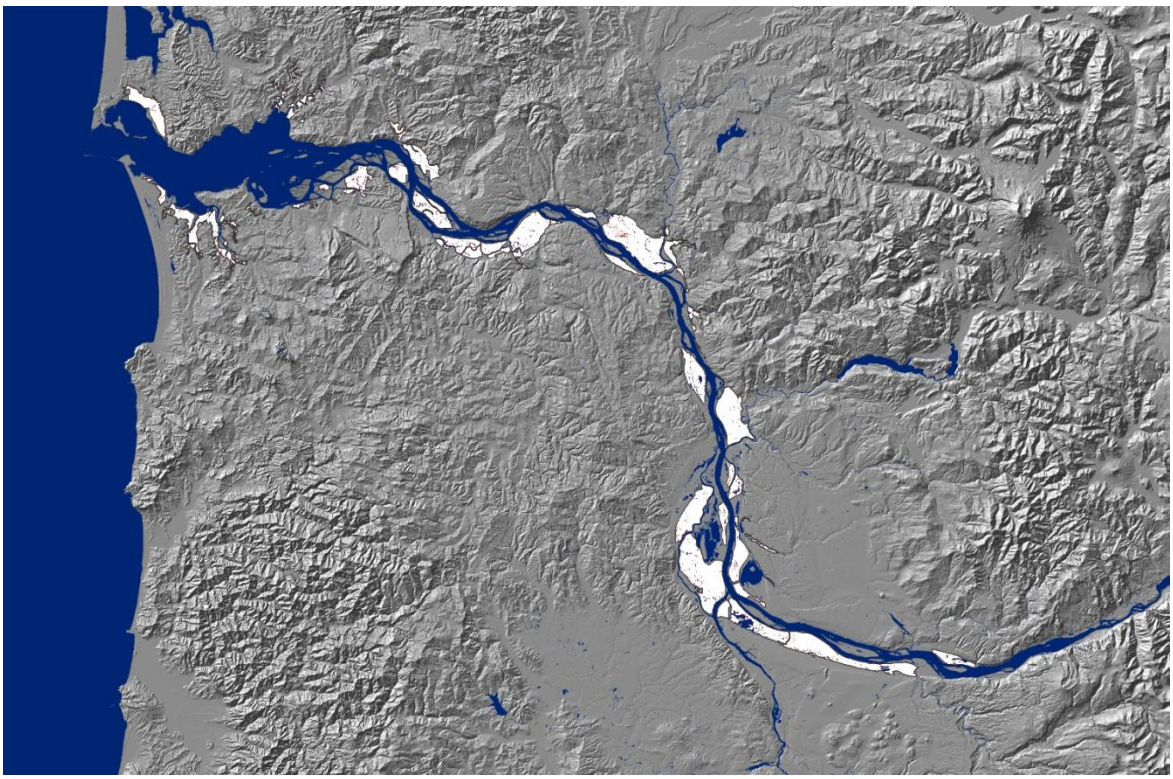


FIGURE 3-1
Diked Areas in the Columbia River Estuary
(Source: Lower Columbia River Estuary Partnership 2005.)

Limiting Factor: Flow-Related Changes in Access to Off-Channel Habitat. Reduced access to off-channel habitats is a limiting factor for salmon and steelhead because of impacts on food webs and the reduced availability of habitats preferred by fry and fingerlings. Typically, overbank flows were driven by spring freshets, which occurred at the time of year when there was the greatest variety of juvenile salmon and steelhead using the estuary (Fresh et al. 2005). Overbank flows occur much less frequently now than they did historically, in part because climate changes and human alterations have reduced the number of high flows in the Columbia (Jay and Kukulka 2003).

Limiting Factor: Bankfull Elevation Changes. The construction of levees also has reduced the frequency of overbank flows because more river water is needed to cause overbank flow. Historically the bankfull level was 18,000 $m^3 s^{-1}$, while today it is 24,000 $m^3 s^{-1}$—fully one-third more. Only five overbank events have occurred since 1948 (Jay and Kukulka 2003). The reduction in overbank events is a limiting factor because it reduces the availability of food and refugia for ocean-type juveniles rearing in the estuary. Less dominant stream-type juveniles are affected in the same manner.

Reduced Plume Habitat Opportunity

Evidence suggests that the plume supports ocean productivity by increasing primary plant production during the spring freshet period, distributing juvenile salmonids in the coastal environment, concentrating food sources such as icthyoplankton (megalopae, for example) and zooplankton, and providing refugia from predators in the more turbid, low-salinity plume waters (Fresh et al. 2005). Changes in the volume and timing of Columbia River flow have altered both the size and structure of the plume during the spring and summer months (Northwest Power and Conservation Council 2000).

Limiting Factor: Flow-Related Plume Changes. For juvenile salmonids preparing for ocean life, the plume is believed to function as habitat, as a transitional saltwater area, and as refugia. As mentioned earlier, stream-type ESUs in particular are affected by the size, shape, behavior, and composition of the plume (Fresh et al. 2005).

Over the past 200 years characteristics of the plume have been altered, and conditions caused by reductions in spring freshets and associated sediment transport processes may now be suboptimal for juvenile salmonids (Casillas 1999). Plume attributes affected by changes in flow include surface areas of the plume, the volume of the plume waters, the extent and intensity of frontal features, and the extent and distance offshore of plume waters (Fresh et al. 2005).

Limiting Factor: Sediment/Nutrient-Related Plume Changes. It is believed that the sediment and nutrients transported in the plume fuel salmon productivity in the ocean and provide relief from predation (Casillas 1999). This is particularly true for stream-type ESUs, who use the plume more extensively than ocean types do and thus are more affected when the amount of plume habitat is reduced.

Limiting Factor: Water Temperature

Higher water temperatures have reduced habitat quality for salmonids that use the estuary during summer months. Since 1938, average summer water temperatures at Bonneville Dam have increased 4° F (2.2° C) (Lower Columbia Fish Recovery Board 2004). Among-year

variability in temperature has been reduced by 63 percent since 1970 (Lower Columbia Fish Recovery Board 2004). As shown in Figure 3-2, temperatures entering the estuary (as measured at Bonneville Dam) have increased steadily since 1938. Temperatures also exceed 20° C (68° F) earlier during the year and more frequently than they did historically (National Research Council 2004).

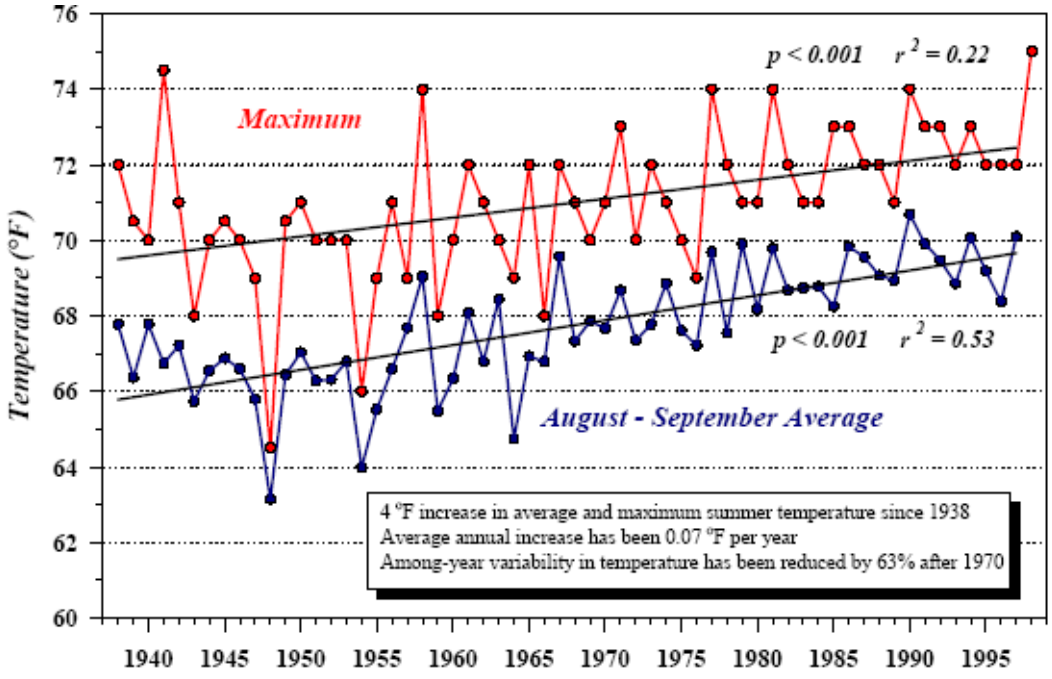


FIGURE 3-2
Temperatures of Water Entering the Estuary
(Reprinted from Lower Columbia Fish Recovery Board 2004.)

(Water temperatures of 20° C (68° F) are considered the upper thermal tolerance limit for cold-water species such as salmonids (National Research Council 2004). Pacific salmon can suffer adverse physiological and behavioral effects as a result of persistent, intermittent, or cumulative exposure to high water temperatures, or from increased daily variation in water temperature (McCullough 1999). Temperatures above 18° C (64.4° F) can impair the metabolism, growth, and disease resistance of salmonids, as well as alter the timing of adult migrations, fry emergence, and smoltification (McCullough et al. 2001, Sauter et al. 2001). Other effects of high water temperatures include adult mortality, reduced pre-spawning survival of eggs and sperm, difficulty competing with non-salmonid fish, prevention or reversal of smoltification, and harmful interactions with certain other habitat stressors (Marine 2004, McCullough 1999, Dunham et al. 2001, Materna 2001, McCullough et al. 2001, and Sauter et al. 2001). For example, the toxicity of some contaminants increases at high water temperatures, and levels of dissolved oxygen go down. Adult sockeye have been known to suffer stress and disease as they are exposed to warm water in estuaries, waiting for cool runoff conditions in their natal stream (Independent Scientific Advisory Board 2007). Warmer temperatures may also enhance conditions for warm-water fish that prey on or compete with juvenile salmonids (Independent Scientific Advisory Board 2007) and cause other changes in the estuarine food web.

During the next century, it is likely that global climate change will contribute to continued water temperature rises in the Columbia River basin as precipitation increasingly falls as rain rather than snow, snow pack diminishes, peak flows increase, and late-summer/early-fall flows are reduced (Independent Scientific Advisory Board 2007). (See Chapter 4 for more on the expected effects of global climate change in the Columbia River basin and estuary.)

Limiting Factor: Stranding

In the estuary, large ships passing through the navigational channel produce bow waves that crash against shorelines in Oregon and Washington. Small ocean-type fry and fingerlings rear within inches of shore and may become stranded as waves intersect the bank and recede (Ackerman 2002), although the extent of this problem is unclear. A 1977 study by Washington Department of Fisheries (WDF) observed 2,397 juvenile salmonids—mostly Chinook—stranded as a result of passage of 216 deep draft vessels (Bauersfeld 1977).

A NOAA technical memorandum (Hinton and Emmett 1994) published in 1994 concluded that the problem was not as significant as documented in the WDF report. Hinton and Emmett found only five juvenile salmonids stranded after observing 145 vessels. A third study, conducted for the U.S. Army Corps of Engineers, observed 21 juvenile Chinook salmon stranded at two sites (Ackerman 2002). In one occurrence, 10 juveniles were stranded by one vessel. As part of the channel deepening project being conducted by the U.S. Army Corps of Engineers, a two-part study of stranding was initiated by the University of Washington and the Portland District of the Corps. The study is designed to measure differences in stranding events before and after channel deepening activities. The first study was published in February 2006 (Pearson et al. 2006). In general, the report documents mortality attributed to stranding events for three test sites; it also builds on other work to determine the conditions that increase the likelihood of stranding events.

Early in 2008, the Port of Vancouver enlisted Entrix, Inc., to perform a spatial analysis of beach susceptibility for the stranding of juvenile salmonids by ship wakes (Pearson 2008). The study examined wave characteristics and the geomorphology of the lower river but did not examine nearshore fish density. The purpose of the study was to estimate the number of miles of shoreline that exhibit traits expected to potentially cause stranding. The study concluded that approximately 33 miles of shoreline between the mouth of the river and the city of Vancouver have shoreline characteristics consistent with stranding (Pearson 2008).

Food Web-Related Limiting Factors

Energy released from the Columbia River and the ocean converges in the estuarine and plume environments where, combined with the biological energy of primary plant production, it forms the basis for life in the estuarine ecosystem. Ultimately, energy that is transferred through the estuarine food web begins with sunlight; sunlight, minerals, and nutrients lead to plant growth in primary production; plants are eaten by animals and animals are preyed upon by other animals in secondary production; and dead plants, animals, and their material are broken down and re-integrated into the base of the food web. Salmon and other native species have evolved together in response to the basic inputs of energy and their circulation through the ecosystem. The result has been the development of an intricately structured food web in the estuary that encompasses food sources, food

availability, and inter- and intra-species relationships. Alterations in any one of the elements of the food web, such as food sources or availability, can ripple throughout the ecosystem, reducing habitat capacity and having potentially far-reaching effects on salmonids and other species.

As part of the food web, decomposing materials known as detritus are consumed by juvenile salmonids, either directly or indirectly through other organisms that feed on the detritus (Northwest Power and Conservation Council 2004). There is evidence that a shift in the food base of the estuary—from macrodetrital to microdetrital—has significantly changed the food web and that complex inter- and intra-species relationships have been permanently altered (Northwest Power and Conservation Council 2004). Microdetrital sources favor production of planktonic copepods and other deep-water organisms that are not typically consumed by juvenile salmon (Bottom et al. 2005). Juvenile salmon that rear extensively in the estuary preferentially consume invertebrates from shallow-water and vegetated habitats, where decomposing plant tissue from emergent plants in estuarine wetlands creates macrodetritus (Bottom et al. 2005). Reductions of wetland and foraging habitat, simplification of habitats, and altered sediment inputs have contributed to the changes in detrital sources in the estuary. By disrupting the food web, these conditions have increased competition and predation (Bottom et al. 2005).

Most studies of prey preferences of juvenile salmon using the estuary focus on stream-type fish, which are less likely than ocean types to rear in estuarine habitats for extended periods. Studies that focus on ocean-type salmonids demonstrate that juvenile salmon appear to feed selectively within particular regions of the estuary (Bottom et al. 2005). In freshwater and brackish habitats, juvenile salmon feed extensively on emergent insects such as chironomids (midges) and epibenthic crustaceans such as mysid shrimp and gammarid amphipods (Macneale et al. 2009 and Miller and Simenstad 1997). Farther downstream in higher salinity portions of the estuary, salmon consume epibenthic crustaceans such as gammarid amphipods and harpaticoid copepods (Bottom et al. 2005). According to a University of Washington master's thesis that demonstrated the importance of midge insects in the diet of juvenile Chinook salmon occupying shallow-water habitats in the Columbia River estuary, emerging chironomids were the dominant prey for Chinook of all sizes (Lott 2004). Additionally, the Oregon Department of Fish and Wildlife found migrating yearling Chinook actively feeding on daphnia. The same study found subyearling Chinook and coho feeding on daphnia year-round in the lower Willamette River (Friesen 2005).

Affected salmonids: Ocean-type ESUs are more likely than stream-type juveniles to be affected by food web alterations because of their use of estuary habitats and their longer residency times. Stream-type ESUs are more influenced in the plume environment because of reduced fine-sediment inputs leaving the estuary.

Food Source Changes

As described below, changes in the detrital sources that form the base of the estuarine food web have been significant and represent a limiting factor for salmonids. Figure 3-3 shows a conceptual model of the estuary food web developed by the U.S. Army Corps of Engineers. The historical tidal marsh macrodetritus-based food web is displayed at the top of Figure 3-3, while the current food web, which is based on imported microdetritus, is shown at the bottom.

Limiting Factor: Reduced Macrodetrital Inputs. The estuarine food web formerly was supported by macrodetrital inputs that originated from emergent, forested, and other wetland rearing areas in the estuary (Northwest Power and Conservation Council 2004). Today, detrital sources from emergent wetlands in the estuary are approximately 84 percent less than they were historically (Bottom et al. 2005). The reduction of macrodetritus in the estuary reduces the food sources for juvenile salmonids. As a result, juveniles may have reduced growth, lipid content, and fitness prior to ocean migration or may need to reside longer in the estuary.

Macrodetrital plant production has declined as a result of the construction of revetments along the estuary shorelines, the disposal of dredged material in what formerly were shallow or wetland areas where plant materials or insects could drop into the water, simplification of habitat through the removal of large wood, and reductions in flow. Flow reductions affect detrital sources by limiting the amount and availability of wetlands—areas that normally would be contributing macrodetritus to the food web—and cutting the number of overbank flows. Historically, much of the detrital inputs occurred during overbank events, which provided additional shallow-water habitat for juvenile salmonids and resulted in significant detrital inputs to the estuary. As mentioned earlier, overbank events occur much less frequently today than they did historically.

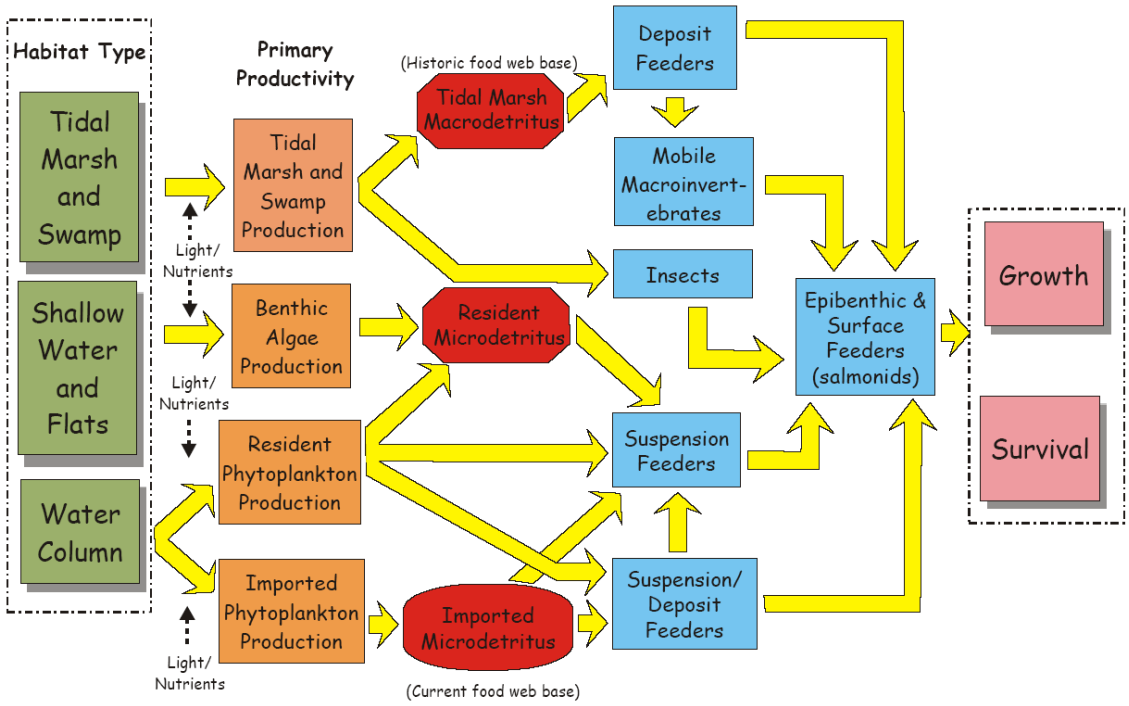


FIGURE 3-3
Conceptual Model of the Columbia River Estuary Food Web

Limiting Factor: Increased Microdetrital Inputs. The current food web is based on decaying phytoplankton delivered from upstream reservoirs and nutrient inputs from urban, industrial, and agricultural development. The amount of this microdetritus has increased dramatically (Bottom et al. 2005). The switch in the estuarine food web from a

macrodetritus-based source to a microdetritus-based source has altered the productivity of the estuary (Bottom et al. 2005).

The substitution of detrital sources in the estuary also has contributed to changes in the spatial distribution of the food web (Bottom et al. 2005). Historically the macrodetritus-based food web was distributed evenly throughout the estuary, including in the many shallow-water habitats favored by ocean-type salmonids. But the contemporary microdetrital food web is concentrated within the estuarine turbidity maximum in the middle region of the estuary (Bottom et al. 2005). This location is less accessible to ocean-type ESUs that use peripheral habitats and more accessible to species such as American shad that feed in deep-water areas.

Pelagic fish such as shad may also benefit from the fact that the estuarine turbidity maximum traps particles and delays their transport to the ocean up to 4 weeks, compared to normal transport of around 2 days (Northwest Power and Conservation Council 2004). The estuarine turbidity maximum is thought to contain bacteria that attach to detritus. Together these represent the primary food source in the estuary today (Northwest Power and Conservation Council 2004).

Competition and Predation

Predation and competition for habitat and prey resources limit the success of juvenile salmonids entering the estuary and plume. Both spatial and energetic losses can involve either density-dependent or density-independent processes (Bottom et al. 2005). Spatial and temporal losses of habitat and large pulses of hatchery juveniles may, under some conditions, result in density-dependent salmonid mortality (Bottom et al. 2005).

Competition among salmonids and between salmonids and other fish may be occurring in the estuary (Lower Columbia Fish Recovery Board 2004), with the estuary possibly becoming overgrazed when large numbers of ocean-type salmonids enter the area. Food availability may be reduced as a result of the temporal and spatial overlap of juveniles from different locations (Bisbal and McConnaha 1998 as cited in Lower Columbia Fish Recovery Board 2004).

Ecosystem-scale changes in the estuary have altered the relationships between salmonids and other fish, birds, and mammal species, both native and exotic. Some native species' abundance levels have decreased from historical levels—perhaps to the point of extinction—while others have increased to levels far exceeding those in recorded history, with associated changes in predation of salmon and steelhead juveniles.

The presence of non-indigenous fish, invertebrates, and plants in species assemblages indicates major changes in aquatic ecosystems (Northwest Power and Conservation Council 2004). Globally the introduction of such species is increasing, a fact that is attributable to the increased speed and range of world trade, which facilitates the transport and release—whether intentional or not—of non-indigenous species (Northwest Power and Conservation Council 2004). In the estuary, the introduction of exotic species has altered the ecosystem through competition, predation, disease, parasitization, and alterations in the food web.

Non-native species affect ocean-type ESUs more than they do stream-type ESUs because of the ocean types' longer juvenile estuary residency times and use of shallow-water habitats.

Limiting Factor: Native Fish. The northern pikeminnow is a native piscivorous fish that preys on juvenile salmonids in the estuary. Although pikeminnows have always been a significant source of mortality for juvenile salmonids in the Columbia River, changes in physical habitats may have created more favorable conditions for predation (Northwest Power and Conservation Council 2004). These changes include reduced flows and favorable micro-habitats formed by pilings, pile dikes, and other over-water structures. The diet of pikeminnows varies with age, with the largest adults representing the biggest risk to juvenile salmonids. Both ocean-type ESUs and stream-type ESUs are affected, but for different reasons. Ocean-type juveniles are susceptible because of their longer estuary residency times and use of shallow-water habitats. Stream-type juveniles are susceptible because they are leaving faster, deeper water to forage for food in shallow areas that are frequented by pikeminnow.

Limiting Factor: Native Birds. As a result of estuary habitat modifications, the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species has increased (Fresh et al. 2005). In 1997 it was estimated that avian predators consumed 10 to 30 percent of the total estuarine salmonid smolt production in that year (Northwest Power and Conservation Council 2004). The 2007 season summary of *Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River* (Roby et al. 2008) estimates that 5.5 million juvenile salmonids were consumed by terns in 2007. Stream-type juvenile salmonids are most vulnerable to avian predation by Caspian terns because the juveniles use deep-water habitat channels that have relatively low turbidity and are close to island tern habitats (Roby et al. 2008). Double-crested cormorants are estimated to have consumed an average of 7 million juvenile salmonids annually over the years 2001 to 2009. Cormorant predation has increased in the past several years and has been as high as 11 million, in 2009 (Fredricks 2010).

Limiting Factor: Native Pinnipeds. The abundance of native pinnipeds has steadily increased since passage of the Marine Mammal Protection Act in 1972. Harbor seals, Steller sea lions, and California sea lions all prey on salmon and steelhead in the estuary (Northwest Power and Conservation Council 2004). Diet studies indicate that pinnipeds consume both juvenile and adult salmonids. U.S. Army Corps of Engineers' annual estimates of adult mortality that occurs at Bonneville Dam because of pinnipeds (primarily California sea lions) ranged from 0.4 percent (2002) to 4.2 percent (2007) during the study period ending in 2010 (U.S. Army Corps of Engineers 2010).[5] Other, radio telemetry-based studies suggest that annual pinniped predation on spring Chinook and winter steelhead at Bonneville Dam may be as high as 8.5 percent and 20 percent, respectively (NMFS 2008b, Appendix G). These estimates do not account for pinniped mortality occurring downstream of Bonneville Dam. There are no official estimates of downstream mortality on adult spring Chinook and winter steelhead (both of which are stream-type salmonids); however, unsubstantiated estimates are as high as 10 percent.

Limiting Factor: Exotic Fish. At least 37 exotic fish species are now found in the Columbia River estuary (Northwest Power and Conservation Council 2004). American shad were introduced into the Columbia River in the 1880s, and adult returns now exceed 4 million in

[5] Estimated consumption of adult salmonids ranged from a low of 1,010 in 2002 to a high of 6,081 in 2010; the percent of run consumed varied among reporting years because of changes in run size.

a single year (Northwest Power and Conservation Council 2004). While shad do not eat salmonids, they exert tremendous pressure on the estuary food web given the sheer weight of their biomass. Some evidence suggests that planktivorous American shad have an impact on the abundance and size of *Daphnia* in Columbia River mainstem reservoirs (Haskell et al. 2006 in Independent Scientific Advisory Board 2008), thereby reducing this important food source for subyearling fall Chinook. Other exotic fish in the estuary, such as smallmouth bass, walleye, and catfish, are piscivorous; however, their abundance levels are relatively small.

Limiting Factor: Introduced Invertebrates. Twenty-seven non-native invertebrate species have been observed in the estuary and documented by the Lower Columbia River Aquatic Non-indigenous Species Survey (Sytsma et al. 2004). Surveys have documented that the estuarine copepod community has changed from a system dominated by a single introduced species, *Pseudodiaptomis inopinus*, to a system dominated by two newly introduced Asian copepods: *Pseudodiaptomis forbesi* and *Sinoclaanus doerri* (Santen 2004). In some cases, the abundance of non-native invertebrates can alter food webs through their wide distribution and key role in the food chain (Northwest Power and Conservation Council 2004).

Limiting Factor: Exotic Plants. The introduction of non-indigenous plant species also has altered the estuary ecosystem. Exotic plant species often out-compete native plants, which results in altered habitats and food webs (Northwest Power and Conservation Council 2004). About 18 aquatic plants have been introduced into the estuary since the 1880s (Sytsma et al. 2004). Examples of non-indigenous plant species include purple loosestrife, Eurasian milfoil, parrot feather, and Brazilian elodea. In addition to out-competing native plants, introduced plant species can contribute to poor water quality and create dense, monospecific stands that represent poor habitat for native species (Northwest Power and Conservation Council 2004). In turn, these new plant communities may alter insect and detritus production in and around vegetated wetlands.

Toxic Contaminants

The quality of habitats and the food web in the Columbia River estuary is degraded as a result of past and current releases of toxic contaminants (Fresh et al. 2005, Lower Columbia River Estuary Partnership 2007), from both estuary and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, contaminant levels in the estuary are much higher, as the estuary receives contaminants from more than 100 point sources and numerous non-point sources, such as surface and stormwater runoff from agricultural and urban sources (Fuhrer et al. 1996). With the cities of Portland, Vancouver, Longview, and Astoria on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. In 2000, Portland Harbor was placed on the National Priorities List, which designates Superfund sites. Sediments in the river at Portland Harbor are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (Oregon Department of Environmental Quality 2008). Work in recent decades has detected contaminants in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuary's food web (Tetra Tech 1996, Fuhrer et al . 1996, Lower Columbia River Estuary Partnership 2007).

Depending on concentration, exposure to toxic contaminants can kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations of contaminants affect the survival of aquatic species by increasing stress, decreasing fitness, predisposing organisms to disease, delaying development, and disrupting physiological processes such as reproduction and smoltification.

Acute lethal effects of toxic contaminants, such as fish kills in response to accidental discharges or spills, have been reported but are generally rare. However, research by the NMFS Northwest Fisheries Science Center has revealed some notable exceptions in which toxic contaminants may lead to the direct mortality of salmonids, such as the following situations:

- Coho pre-spawn mortality. For the past several years, NMFS has been documenting the recurrent die-offs of adult coho salmon returning to spawn in restored lowland urban streams in the Puget Sound Basin, at rates ranging from 30 to 90 percent of local coho runs (McCarthy et al. 2008). The weight of evidence to date suggests that pollutants in runoff from urban landscapes are causing the fish kills, and the phenomenon is correlated with high densities of roads and vehicle traffic. Based on findings from Puget Sound, coho spawners are likely at risk in urbanizing watersheds in the greater Columbia Basin (particularly the lower Columbia River).
- Synergistic toxicity of pesticide mixtures. A study by NMFS, in collaboration with Washington State University, has shown that common current-use pesticides (organophosphate and carbamate insecticides) produce unexpectedly synergistic toxicity and death in juvenile salmon following short-term exposure (Laetz et al. 2007). These agricultural pesticides are used in most of the major subbasins, and they reach rearing and migration habitats for salmon via spray drift, surface runoff, and irrigation return flows. In a 10-year study by the U.S. Geological Survey, Gilliom (2007) found that mixtures of pesticide compounds are prevalent in streams in watersheds that are dominated by agricultural, urban, or mixed land use.
- Salmon egg mortality. Increased mortality has been observed in salmon eggs exposed to PAHs in oil, such as at sites in Alaska following the Exxon Valdez oil spill (Heintz et al. 1999, Carls et al. 2005). An unpublished study by NMFS suggests that salmon embryos incubated in urban stream water also show relatively high rates of developmental defects and mortality when compared to embryos raised in the same water passed though an in situ streamside filtration system. At this time, the contaminants in the urban stream water are unidentified contaminants that are toxic to salmon embryos and likely pose an important early life stage threat to salmon in urbanizing watersheds.

Although the lethal effects described above are of concern, sublethal effects of contaminants are probably the greatest threat to juvenile salmon in the Columbia River. In juvenile salmonids, contaminant exposure can result in decreased immune function and generally reduced fitness (Northwest Power and Conservation Council 2004, Arkoosh and Collier 2002). Exposure can also impair growth, development, and reproduction and disrupt olfaction; salmonids depend on olfaction for migration, imprinting on natal streams, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects of contaminant exposure may indirectly increase mortality from other factors like

infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (Lower Columbia River Estuary Partnership 2007). Contaminants that affect growth can have significant effects. Juvenile growth is necessary for ocean survival (Zabel and Williams 2002 as cited in Lower Columbia River Estuary Partnership 2007), and adult fish size has been correlated to reproductive success and egg size (Healey and Heard 1983, Beacham and Murray 1987). Low lipid content, which has been observed in outmigrating juvenile Chinook salmon in the Columbia River estuary (Johnson et al. 2007b, Lower Columbia River Estuary Partnership 2007), is another sign of poor growth that is correlated with an increased risk of juvenile mortality (Biro et al. 2004). Thus, toxic contaminants that impair salmonid growth can reduce juvenile survival, adult returns, and individual reproduction. Although many effects of contaminants require an exposure period of weeks to months, some impacts, especially those on behavior, can occur very quickly. For example, effects of pesticides and copper on the salmon olfaction system can be seen after exposure periods of only a few hours (Sandahl et al. 2004 and 2007, Hecht et al. 2007).

Toxic contaminants can also indirectly affect salmon via the food web, especially prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. The availability of prey species is one of the primary determinants of salmonid growth, and reductions in the prey base can affect salmonid survival and productivity (Chapman 1966 and Mundie 1974 as cited in Lower Columbia River Estuary Partnership 2007). Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources.

A study by Loge et al. (2005) in the Columbia River will likely bring more attention to the effects of contaminants on salmonids in the estuary. The study documents infectious disease in outmigrating juvenile salmonids attributed to abiotic stressors, such as chemicals, that influence host susceptibility to infection. The study estimates disease-induced mortalities in Chinook salmon related to exposure to contaminants at 1.5 percent and 9 percent for estuary residence times of 30 to 120 days, respectively (Loge et al. 2005).

Other contaminants, including endocrine-disrupting substances such as synthetic hormones, are beginning to be characterized in the estuary, and these contaminants could have substantial effects on salmon and steelhead (Fresh et al. 2005). A study by the Lower Columbia River Estuary Partnership, aided by NMFS and the U.S. Geological Survey, found emerging contaminants such as caffeine, acetaminophen, and human and veterinary antibiotics in the water column of the estuary and evidence of exposure to estrogenic compounds in the blood of juvenile Chinook salmon (Lower Columbia River Estuary Partnership 2007). Several suspected hormone disruptors were detected in the water column, including bisphenol A (a plasticizer), HHCB (a synthetic musk), and polybrominated diphenyl ethers (PBDEs, which are synthetic flame retardants used in everyday products like plastic, cushions, and fabrics). Although some forms of PBDEs have been banned, PBDE concentrations in the environment have increased exponentially during

recent decades. In the Columbia River estuary, they have been found in the water column, on suspended sediment, and in the tissue and stomach contents of juvenile Chinook salmon, which indicates that salmon prey also are contaminated (Lower Columbia River Estuary Partnership 2007). PBDEs are similar to PCBs in their chemical structure and sublethal effects, such as neurotoxicity and hormone disruption.

Affected salmonids: Contaminant exposure by stream-type and ocean-type salmon likely reflects contaminants present in rearing habitats. Stream-type salmon are apt to have contaminant loads that reflect conditions in the upper Columbia River and its tributaries, while ocean-type salmon are apt to have loads that reflect conditions in the lower river and estuary (Leary et al. 2006, Johnson et al. in prep, Dietrich et al in prep a). It is likely that both stream-type and ocean-type juvenile salmonids are affected by short-term exposure to waterborne contaminants such as organophosphate pesticides and dissolved metals that can have acute effects on salmon olfactory function and behavior (Fresh et al. 2005, Johnson et al. in prep a), and both types could be affected by bioaccumulative legacy pesticides, such as DDTs, that are present throughout the Columbia Basin. Additionally, ocean-type juveniles likely experience adverse effects and possibly mortality from urban and industrial bioaccumulative toxics such as PCBs and PBDEs that are present in the Columbia River estuary and are absorbed during longer estuarine residence times (Fresh et al. 2005). Both life history types could be affected by contaminant impacts on prey resources (Johnson et al. in prep). Preliminary data tend to support the hypothesis that contaminant body burdens are generally higher in ocean-type stocks than in stream-type stocks (Johnson et al. 2007a) and higher in outmigrating subyearling Columbia River Chinook than in yearlings, especially for industrial contaminants such PCBs and PBDEs that are present at higher concentrations in the Columbia River estuary (Lower Columbia River Estuary Partnership 2007, Dietrich et al. 2008). However, more work is needed on contaminant uptake and impacts on salmon of different stocks and life history types.

Limiting Factor: Bioaccumulation Toxicity. Bioaccumulative and potentially toxic waterborne contaminants, trace metals, and chlorinated compounds have been observed in the estuary (Fuhrer et al. 1996, Fresh et al. 2005, Lower Columbia River Estuary Partnership 2007). DDT and PCBs have been detected in juvenile salmon from the estuary at concentrations above threshold levels for health effects, and in salmon stomach contents and water quality samples from sites throughout the estuary (Lower Columbia River Estuary Partnership 2007). DDT, PCBs, and trace metals such as copper all bioaccumulate and concentrate in animals near the top of the food chain.

Loge et al. (2005) estimated disease-induced, contaminant-related mortalities at 1.5 percent and 9 percent for juvenile Chinook residing in the Columbia River estuary for 30 to 120 days, respectively (Loge et al. 2005). Figures 3-4 and 3-5 show concentrations of PCBs and DDTs found in the stomach contents of subyearling fall Chinook in several locations of the Columbia River estuary, other Pacific Northwest sites, and hatcheries.

Limiting Factor: Non-Bioaccumulative Toxicity. A variety of organochlorines (including trichlorobenzene, the insecticides aldrin and dieldrin, and PAHs) in the estuary are above state and Federal guidance levels (Northwest Power and Conservation Council 2004). These contaminants tend not to bioaccumulate in salmon and steelhead (although PAHs do bioaccumulate in invertebrates), but they are readily absorbed and can have sublethal

effects. Copper also was detected in juvenile salmon, at concentrations that can impair olfaction (Lower Columbia River Estuary Partnership 2007). In addition, copper can interact with other toxic contaminants—mercury, aluminum, iron, and certain pesticides—to cause synergistic effects, such that the combined toxicity is greater than the toxicity predicted based on the sum of the contaminants present (Eisler 1998 as cited in Lower Columbia River Estuary Partnership 2007).

As mentioned above, sublethal concentrations of contaminants can affect the survival of aquatic species by increasing stress, predisposing organisms to disease, delaying development, and disrupting physiological processes (Northwest Power and Conservation Council 2004). Exposure to PAHs may be a particular problem for salmon in the urbanized portions of the estuary, as these contaminants are very common in stormwater as well as in industrial discharges. Although salmonids can break down PAHs, the metabolites of PAHs can be mutagenic and carcinogenic, especially in cases of chronic exposure. PAHs also can contribute to immune dysfunction in juvenile salmon (Arkoosh and Collier 2002, Bravo et al. 2008) and cause alterations in growth and metabolism that could increase the risk of mortality (Meador et al. 2006 and 2008). Figure 3-6 shows concentrations of PAHs in the stomach contents of subyearling fall Chinook in various locations of the Columbia River estuary, other Pacific Northwest sites, and hatcheries.

One study detected numerous currently used pesticides present in water quality samples from sites throughout the estuary, with the most frequently detected pesticides being the suspected hormone disruptors atrazine, simazine, and metolachlor (Lower Columbia River Estuary Partnership 2007). Exposure to individual pesticides has sublethal effects on salmon behavior, interfering with predator avoidance, altering homing and migration, and reducing egg fertilization. Health effects include reduced olfactory function, impaired growth, and immune suppression. Pesticides also can be toxic to salmon prey.

Although the concentrations of the individual pesticides detected in the study were lower than threshold levels for health effects in juvenile salmonids, pesticides often were found in combination (Lower Columbia River Estuary Partnership 2007). This is of concern because some pesticides are known to have additive effects. For example, when common pesticides such as diazinon, chlorpyrifos, and carbaryl occur together, even if each is at a relatively low concentration, their combined concentration can have toxic effects on fish and wildlife (Scholz et al. 2006 as cited in Lower Columbia River Estuary Partnership 2007). Among salmonids, carbamate and organophosphate pesticides can have additive effects on olfactory function (Scholz et al. 2006 as cited in Lower Columbia River Estuary Partnership 2007). Some studies suggest that synergistic effects may also be occurring when current-use pesticides occur together in the environment (Anderson and Zhu 2004 and Denton et al. 2003 as cited in Lower Columbia River Estuary Partnership 2007). This is a reminder that the effects of toxic contaminants in the estuary may not be directly proportional to measured concentrations.

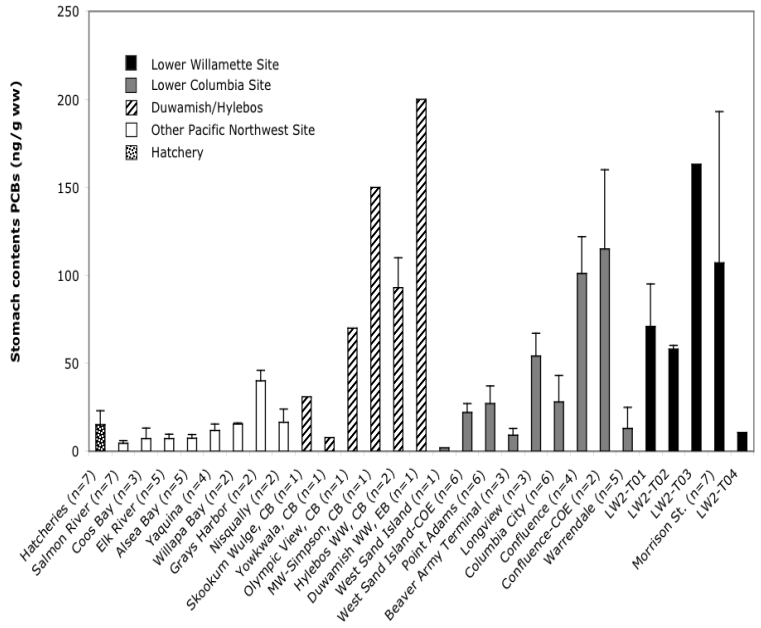


FIGURE 3-4
Concentrations of PCBs in the Stomach Contents of Subyearling Fall Chinook

(From Johnson et al. 2007a and 2007b, Lower Columbia River Estuary Partnership, Olson et al. 2008, Stehr et al. 2000, and Lower Willamette Group 2007)

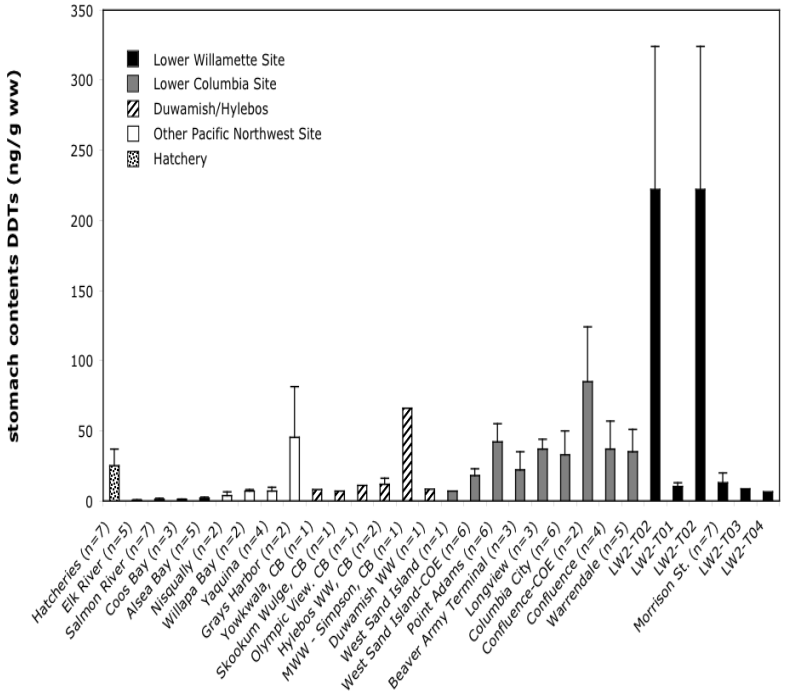


FIGURE 3-5
Concentrations of DDTs in the Stomach Contents of Subyearling Fall Chinook

(From Johnson et al. 2007a and 2007b, Lower Columbia River Estuary Partnership, Olson et al. 2008, Stehr et al. 2000, and Lower Willamette Group 2007)

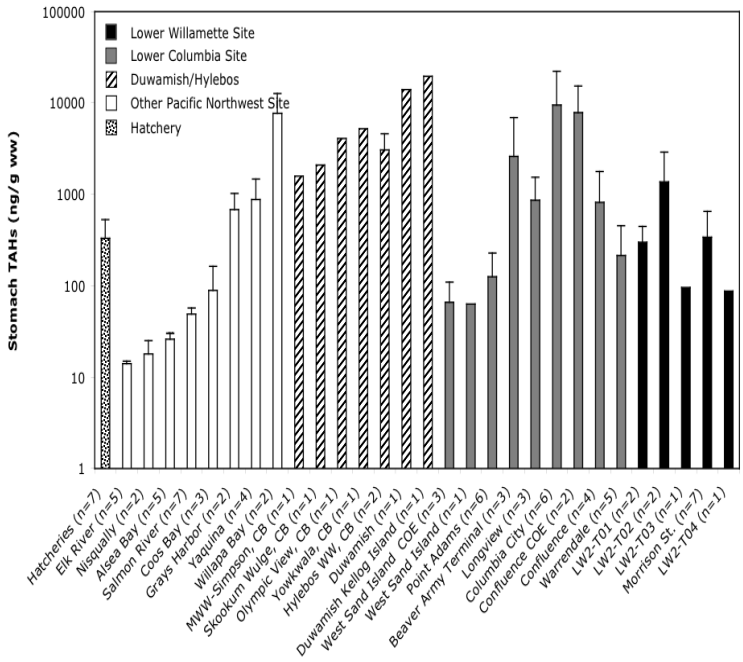


FIGURE 3-6
Concentrations of Total Aromatic Hydrocarbons (PAHs) in the Stomach Contents of Subyearling Fall Chinook

(From Johnson et al. 2007a and 2007b, Lower Columbia River Estuary Partnership, Olson et al. 2008, Stehr et al. 2000, and Lower Willamette Group 2007)

Habitat Opportunity, Habitat Quality, and Synergistic Effects

A lack of habitat opportunity and reduced habitat quality both play a role in limiting the viability of salmon and steelhead in the Columbia River estuary. In terms of habitat opportunity, changes in the timing and volume of Columbia River flows, combined with higher bankfull elevations, have reduced the amount and accessibility of in-channel, off-channel, and plume habitat. Overbank flooding that normally would aid juveniles in accessing off-channel refugia and food resources has been virtually eliminated, and sediment transport processes that structure habitat have been impaired.

Meanwhile, the quality of the habitat available to salmon and steelhead in the estuary has been compromised. Water temperatures are relatively high for cold-water species such as salmon and steelhead and are expected to continue to climb. Researchers have found a variety of toxic contaminants in water, sediments, and salmon tissue in the estuary. With changes in vegetation and flow, juvenile salmonids' traditional macrodetrital food sources have become scarcer and the food base has switched to a microdetritus-based source, thus altering the productivity of the estuary. Predation by northern pikeminnow, pinnipeds, Caspian terns, and cormorants has increased, and it is likely that the presence of native and exotic fish, introduced invertebrates, and invasive plant species is further altering food web dynamics. These and other changes in habitat quality make the estuary a very different place for salmon and steelhead than it was historically.

Habitat quality often is influenced by features that this analysis considers aspects of habitat opportunity, such as river flow and sediment processes. As one example, alterations in flow

have eliminated much of the vegetated wetlands that ordinarily would supply insect prey for juvenile salmonids and macrodetrital inputs to the estuarine food web. In some cases it may not be not be possible to improve habitat quality without reducing limiting factors related to habitat opportunity. Likewise, it may be necessary to address habitat quality issues, such as toxic contaminants, before increasing access to habitat that could be contaminated.

This type of interplay between habitat opportunity and habitat quality is a reminder of how connected limiting factors in the estuary are, even though this chapter describes them discretely. It is possible that some of the limiting factors have synergistic effects, in which the cumulative negative impact of two or more limiting factors is greater than the sum of the impacts of the individual limiting factors. This likely is the case with flow reductions and increases in bankfull elevation, which combine to limit juveniles' access to off-channel habitats. Although synergistic effects are difficult to identify and quantify, the estuary recovery plan module assumes that they exist and that they can be taken advantage of to enhance the beneficial impacts of management actions in the estuary. Chapter 7 addresses the implications of potential synergistic effects more directly.

Prioritization of Limiting Factors

This estuary recovery module uses a 1-to-5 rating system to prioritize limiting factors by ocean- and stream-type salmon and steelhead, at the estuary scale. PC Trask & Associates, Inc., performed an initial prioritization, based on a synthesis of the three main literature sources (Bottom et al. 2005, Fresh et al. 2005, and Northwest Power and Conservation Council 2004), supplemented by additional literature. (See the discussion of each limiting factors for specific source material.) Staff from the Lower Columbia River Estuary Partnership, NMFS Northwest Fisheries Science Center, NMFS Northwest Regional Office, and Lower Columbia Fish Recovery Board reviewed and provided input on the prioritization.

All three of the main literature sources used in this estuary recovery module identify flow, sediment, water quality, and food web alterations as limiting factors. *Salmon at River's End* (Bottom et al. 2005) analyzes each of the limiting factor categories in the context of habitat opportunity and capacity and how the limiting factor fits within the member/vagrant conceptual framework. The Fresh technical memorandum evaluates selected limiting factors (tern predation, toxics, habitat, and flow) for their impacts on ocean- and stream-type ESUs (Fresh et al. 2005). Finally, the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" and its supplement (Northwest Power and Conservation Council 2004) evaluate limiting factors for their impacts to salmonids and the level of certainty that the factor is limiting. Of the limiting factors identified in this module, the only one not identified in at least one of the three main documents is stranding, which the author researched at the suggestion of Washington Department of Fish and Wildlife staff.

In prioritizing limiting factors, the author considered the following: (1) how the three main literature sources evaluated and/or prioritized limiting factors, (2) the magnitude or severity of limiting factors as described in the source documents, (3) estimates of mortality caused by a limiting factor, which were available only for predation-related limiting factors, and (4) the frequency with which a limiting factor was identified in the source documents.

Limiting factors were prioritized individually, without trying to account for potential negative synergistic effects, which are difficult to evaluate.

Table 3-1 shows the results of the limiting factor rating process. Each limiting factor received two scores—one for ocean-type salmonids and one for stream-type salmonids. One simplifying assumption in scoring is that both ocean- and stream-type salmonids express a diversity of life history strategies within ESUs and their constituent populations. Relative scores between ocean- and stream-type salmonids generally reflect the dominant life history stage by providing extra weight to the dominant life history strategy; however, less dominant strategies are considered. For example, reduced off-channel habitat is primarily a limiting factor for ocean-type juveniles because the dominant life history strategy is subyearlings that use shallow-water habitats extensively to feed and rear. However, some ocean-type populations and subpopulations also express a yearling strategy as part of the overall genetic makeup of the population. As a result, both ocean- and stream-type salmonids received scores (albeit lower) for other less dominant life history strategies. The far right-hand column of the table is the total score, which adds ocean- and stream-type impact scores into a single composite score. The assumption that within healthy ESUs there is expression of less-dominant life history strategies is central to *Salmon at River's End* (Bottom et al. 2005) and the Fresh technical memorandum.

Table 3-2 organizes limiting factors into groups based on total score. Top-priority limiting factors are those that have the greatest impact on both ocean- and stream-type ESUs, while lowest priority limiting factors have the least combined impact to ocean- and stream-type ESUs. An important assumption in the rating system is that all limiting factors had an effect on one or both ESU types.

The prioritization of limiting factors in this module should be considered a working hypothesis to be tested and refined through research and evaluation (including a formal expert opinion, or "Delphi," process). Future planning efforts would also be enhanced by a limiting factors analysis at the reach or sub-reach scale, although information is generally not available at this time to consistently identify limiting factors at these finer scales. (In Chapter 5, priority reaches are identified for the 23 management actions.)

Summary

The identification of limiting factors in the Columbia River estuary is well supported in a variety of literature sources, although additional research is needed to understand the relative impacts of the limiting factors and their interactions. Source documents take different approaches to lumping limiting factors together or splitting them apart for the purposes of evaluation, but all of the documents generally agree that channel confinement and alterations to flows and sediment have significantly degraded the estuary ecosystem in far-reaching ways. Water quality and food web limiting factors also are well documented.

The interconnectedness of these limiting factors suggests the use of ecosystem-based analysis to understand more exactly their effects on salmonids; however, at this point modeling efforts cannot fully explain the complex relationships among limiting factors.

The next chapter examines human actions and natural events that cause or contribute to the limiting factors described in Chapter 3.

TABLE 3-1
Impact of Limiting Factors on Ocean- and Stream-Type Salmonids

Limiting Factor	Level of Impact		
	Ocean Type*	Stream Type*	Total Score
Habitat-Related Limiting Factors			
Reduced in-channel habitat opportunity			
Flow-related estuary habitat changes	5	3	8
Sediment/nutrient-related estuary habitat changes	4	3	7
Reduced off-channel habitat opportunity			
Flow-related changes in access to off-channel habitat	5	3	8
Bankfull elevation changes	5	2	7
Reduced plume habitat opportunity			
Flow-related plume changes	3	5	8
Sediment/nutrient-related plume changes	2	3	5
Water temperature	5	3	8
Stranding	3	2	5
Food Web-Related Limiting Factors			
Food Source Changes			
Reduced macrodetrital inputs	5	3	8
Increased microdetrital inputs	3	2	5
Competition and Predation			
Native fish	3	3	6
Native birds	2	5	7
Native pinnipeds	2	5	7
Exotic fish	2	2	4
Introduced invertebrates	2	2	4
Exotic plants	2	2	4
Toxic Contaminants			
Bioaccumulation toxicity	4	2	6
Non-bioaccumulative toxicity	4	3	7

*Significance of limiting factor to life history strategy:
1 = No likely effects.
2 = Minor effects on populations.
3 = Moderate effects on populations.
4 = Significant effects on populations.
5 = Major effects on populations.

TABLE 3-2
Limiting Factor Prioritization

Limiting Factor	Limiting Factor Score[a]	Limiting Factor Priority[b]
Flow-related estuary habitat changes	8	Top
Flow-related changes in access to off-channel habitat	8	
Flow-related plume changes	8	
Water temperature	8	
Reduced macrodetrital inputs	8	
Sediment/nutrient-related estuary habitat changes	7	High
Bankfull elevation changes	7	
Native birds	7	
Native pinnipeds	7	
Non-bioaccumulative toxicity	7	
Native fish	6	Medium
Bioaccumulation toxicity	6	
Sediment/nutrient-related plume changes	5	Low
Stranding	5	
Increased microdetrital inputs	5	
Exotic fish	4	Lowest
Introduced invertebrates	4	
Exotic plants	4	

[a]From Table 3-1.
[b]Limiting factors have been prioritized in groups, rather than individually, to avoid a false sense of precision in this qualitative analysis.

CHAPTER 4

Threats to Salmonids

Chapter 4 identifies and prioritizes threats to ESUs in the Columbia River basin. Threats are the human actions or natural events, such as volcanic eruptions or floodplain development, that cause or contribute to limiting factors (Gaar 2005). Threats may be caused by past, present, or future actions or events.

PC Trask & Associates, Inc., identified and prioritized threats using the same process and sources used to identify and prioritize limiting factors—that is, a thorough review and synthesis of pertinent literature (particularly Bottom et al. 2005, Fresh et al. 2005, and Northwest Power and Conservation Council 2004), supplemented with input from staff at the NMFS Northwest Fisheries Science Center and Northwest Regional Office, Lower Columbia River Estuary Partnership, and Lower Columbia Fish Recovery Board. The module's three key source documents and a number of other sources document both limiting factors and threats. In most cases the literature addresses limiting factors and threats together, and it required substantial effort to separate them for the purposes of this estuary recovery plan module.

The one threat presented in this chapter that the three main source documents do not mention is ship wakes, which can cause stranding of juvenile salmonids. Although the topic of stranding was first raised in a 1977 report (Bauersfeld 1977), the extent of stranding remains unclear. Washington Department of Fish & Wildlife staff suggested that the topic be addressed in this recovery plan module.

The relationship between limiting factors and threats is not necessarily one-to-one. A single threat can contribute to several limiting factors, and in many cases a limiting factor exists because of the effects of multiple and varied threats. (Table 4-1, which is presented later in this chapter, shows the linkages between the limiting factors in Chapter 3 and the threats described in Chapter 4.) For ease of understanding, this chapter organizes threats to salmonids into the following groupings: flow, sediment, structures such as dikes and jetties, ship wakes, food web (including species relationships), and water quality in the estuary. The presentation of threats as discrete activities or phenomena is an oversimplification of complex physical and biological relationships that affect salmon survival. The threats related to flow, sediment transport, and food webs are particularly difficult to tease apart and discuss discretely. Thus the reader should bear in mind that describing threats individually does not fully capture the dynamic interplay of forces that are currently putting salmonids in the estuary at risk. The complexity of these forces is illustrated in Figure 4-1, which is a representation of a conceptual model of the Columbia River estuary developed by the U.S. Army Corps of Engineers (Diefenderfer et al. 2005). The model provides in-depth detail on the relationships between limiting factors and threats.

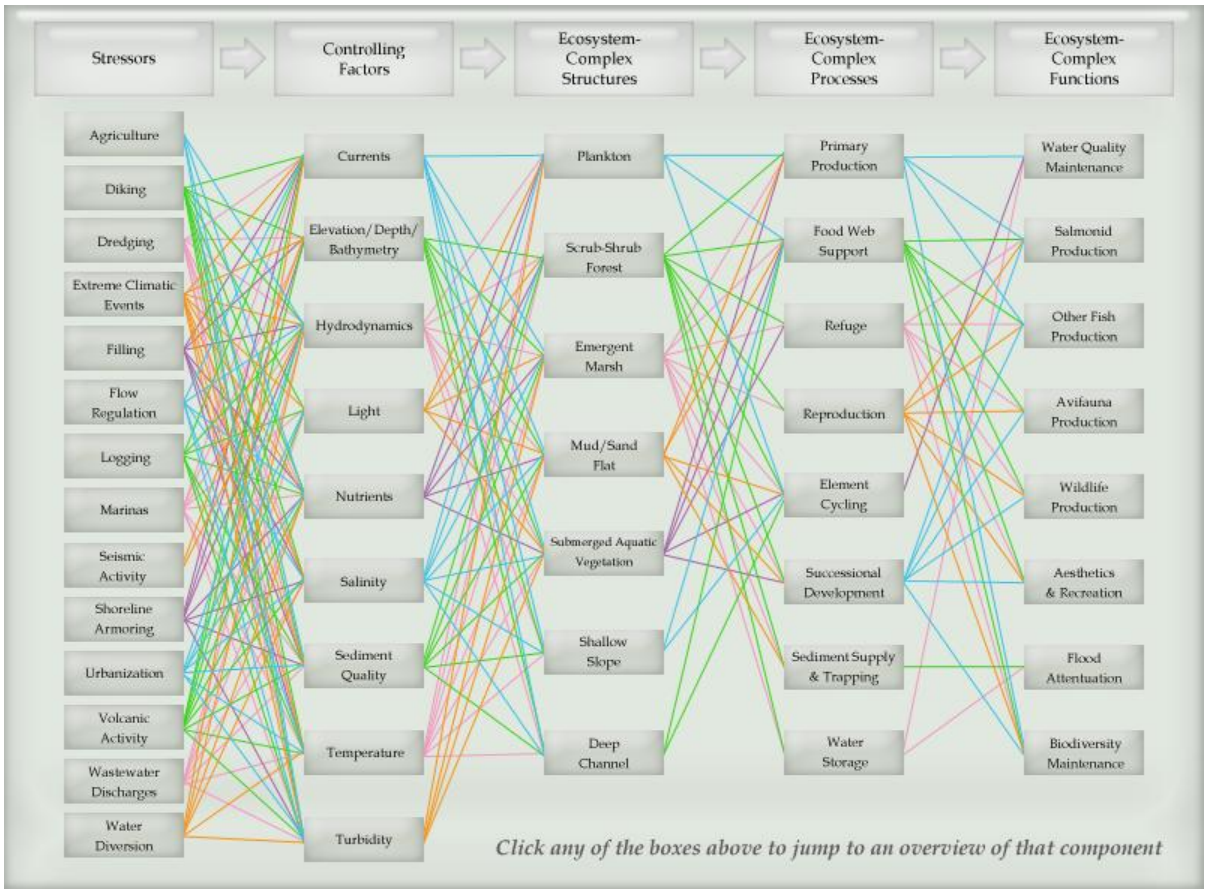


FIGURE 4-1
Conceptual Model of the Columbia River Estuary
(Note: "Stressors" are equivalent to threats as defined in this module.)
(Figure provided courtesy of the U.S. Army Corps of Engineers.)

Most of the human threats described in this chapter are the result of the cumulative impacts of European Americans living in the Northwest. From an ecological perspective these impacts have taken place relatively quickly. Consider that in 1770, when American Robert Gray first crossed the Columbia River bar, about 100,000 Native Americans lived in the Columbia River basin (Oregon State University 1998). Today the population of the Columbia Basin is approximately 5 million (National Research Council 2004). In the early years of Euro-American settlement, the area's abundant natural resources supported farming, mining, logging, fishing, and other activities that modified the landscape into productive uses for people. Later, the availability of cheap hydroelectric power helped fuel expanded agriculture, manufacturing, and development and the rise of urban centers such as Portland. The impacts of these activities on salmonids in the estuary have been substantial.

Flow-Related Threats

Over the last 4,000 years, salmon thrived in the Columbia River by adapting to habitats created by characteristics of the land and water flow (Fresh et al. 2005). Key attributes of flow include magnitude and timing, both of which have changed significantly in the

Columbia River over the last two centuries. Today the mean flow to the estuary is about 16 percent less than it was in the latter part of the nineteenth century (Jay and Kukulka 2003), and spring freshet peak flows have declined about 44 percent in that same time period (Jay and Kukulka 2003). In addition, the timing of peak flows occurs about 14 to 30 days earlier than it did historically (Jay and Kukulka 2003). Reductions in the spring freshet flows are shown in Figure 4-2, which presents simulated mean monthly discharge at Bonneville Dam before development of the hydrosystem and under current hydrosystem configurations and operations.

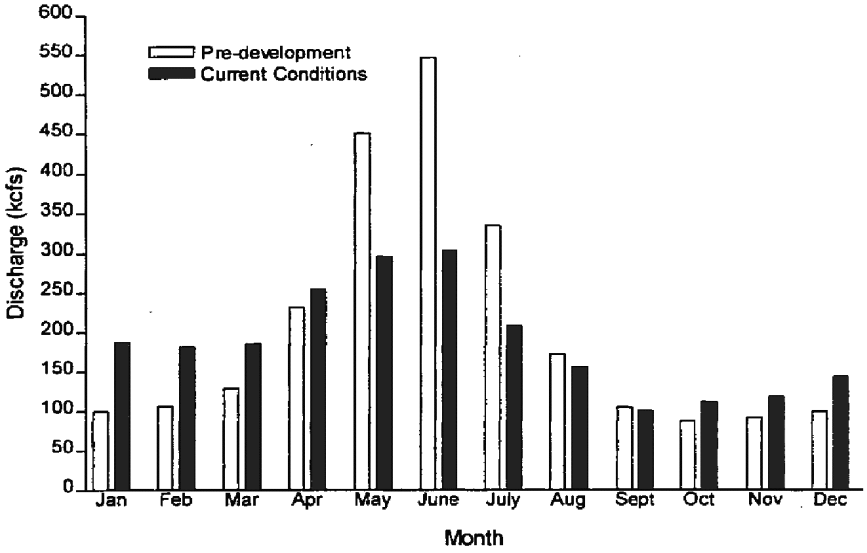


FIGURE 4-2
Changes in the Annual Columbia River Flow
(Adapted from National Marine Fisheries Service 2000.)

Flow alterations, in connection with other factors, can increase or decrease salmonids' ability to access habitats and the capacity of habitats to sustain salmonids (Bottom et al. 2005). In the case of the Columbia River, alterations in the timing, magnitude, and duration of flows are responsible for dramatic changes in habitat opportunity and capacity in the estuary, including effects on groundwater recharge, cold-water upwelling, flooding, off-channel habitat quality and quantity, and water quality. Climate fluctuations, the withdrawal of water, and regulation of river flow have altered the amount and timing of instream flows entering the estuary and plume.

Affected salmonids: Alterations in the magnitude and timing of Columbia River flows affect both ocean- and stream-type juvenile salmonids. Ocean-type juveniles spend more time in the estuary, where they rely on shallow vegetated marsh habitats and upland swamp habitats (Northwest Power and Conservation Council 2004). Chum salmon (ocean-type) also spawn in the mainstem and are affected by low flows during the spawning and egg incubation life stages. In extreme cases, redds may have been dewatered; however, a minimum flow now has been administratively set from November through April to reduce the potential for dewatering of chum redds located immediately below Bonneville Dam. Ocean-type salmonids also rely on seasonal overbank flows to access habitats and preferred food sources.

Stream-type juveniles do not spend much time in the estuary, but research indicates that they may use the Columbia River plume habitat as they adjust to saltwater conditions (Fresh et al. 2005). Columbia River flows have a direct effect on the plume's surface area, volume, frontal features, and extent offshore (Fresh et al. 2005). Flow alterations also affect sediment transport processes and water quality.

Threat: Climate Cycles and Global Climate Change

Natural variations in Columbia River flow as a result of long- and short-term climate fluctuations have occurred throughout history. The Pacific Decadal Oscillation (PDO) alternates between cold and warm phases approximately every 30 years (Fresh et al. 2005). The cold, rainy phase is typical of the Northwest and increases flows, while the warm phase is drier and decreases flows (Fresh et al. 2005). The El Niño/Southern Oscillation (ENSO) is a shorter, 3- to 7-year phenomenon that similarly has cold and warm phases that may magnify or reduce the effects of the PDO.

Climatic fluctuations have a significant effect on the amount and timing of water flowing to the estuary (Fresh et al. 2005). Since 1878, climatic changes have reduced Columbia River flows by 9 percent (Jay and Kukulka 2003). The NMFS Northwest Fisheries Science Center has observed changes in PDO and ENSO indicators that suggest that changes in ecosystem structure can be expected that are unfavorable for salmon and steelhead (Varanasi 2005). These changes may continue over the next several years.

Scientists believe that the release of high levels of carbon dioxide as a result of human activities is contributing to global climate change. The source of these releases includes the use of fossil fuels to run cars, heat homes and offices, and power factories. Over the past century, global climate change has caused sea levels to rise about 4 to 5 inches (10 to 13 centimeters), worldwide precipitation to increase by about 1 percent, and the frequency of extreme rainfall events to increase in much of the United States (U.S. Environmental Protection Agency 2005). Sea level rise is predicted to accelerate worldwide in the coming decades as a result of global climate change (Intergovernmental Panel on Climate Change 2007). The Intergovernmental Panel on Climate Change has observed that sea levels rose at an average rate of 1.8 millimeters per year from 1961 to 2003 and may be 0.18 to 0.59 meter (0.6 to 1.9 feet) higher at the end of the 21st century than they were during the baseline period of 1980 to 1999 (Intergovernmental Panel on Climate Change 2007).

The Independent Scientific Advisory Board for the Northwest Power and Conservation Council (2007) reports that the Pacific Northwest has warmed about 1° C (1.8° F) since 1900 (this is about 50 percent more than the global average for the same time period) and is projected to warm at a rate of 0.1 to 0.6° C (0.18 to 1.1° F) per decade during the next century. Over the long term, winter precipitation is expected to increase, and summer precipitation is expected to decrease. Within the Columbia River basin, expected effects of rising temperatures include more precipitation falling as rain rather than snow, diminished snow pack, associated reductions in late-summer/early-fall flow, altered timing of flows, increased peak flows, and continued rises in water temperatures. In the estuary, these factors could lead to changes in flooding and ecosystem processes and conditions that already are considered limiting factors for salmon and steelhead—namely, flow-related habitat changes, sediment transport, food web dynamics, populations of non-native species, and water temperature (Independent Scientific Advisory Board 2007). Increasingly, water

temperatures in the estuary are approaching the upper thermal limit for salmonids that use the estuary during summer months (National Research Council 2004). Further increases in water temperature could render some current estuarine habitat unsuitable for salmonids, enhance conditions for warm-water fish that prey on or compete with juvenile salmonids, and alter physiological processes such as growth and metabolism among juveniles (Independent Scientific Advisory Board 2007). Some evidence suggests that salmonid response to climate change varies among populations (Crozier and Zabel 2006 as cited in Independent Scientific Advisory Board 2007). Other potential impacts of global climate change in the estuary may include continued rises in sea level and associated effects on intertidal habitat formation and maintenance.

Study of the impacts of global climate change is an evolving field, and additional research is needed to understand the phenomenon's likely effects on estuarine habitats and processes with specificity. Although the estuary recovery plan module does not consider global climate change separately from other climate-related impacts in the estuary, the topic should receive increasing attention for its potential to affect fish management in the Columbia River basin as a whole. As additional scientific information on global climate change becomes available, it will be incorporated into any updates of the estuary recovery plan module and implementation of associated management actions.

Limiting factors this threat contributes to: Flow-related estuary habitat and plume changes, flow-related changes in access to off-channel habitat, water temperature, and reduced macrodetrital inputs.

Threat: Water Withdrawal

Reduction in the amount of instream flow in a river system is an important measure of alterations to the system (Fresh et al. 2005). Water withdrawals affect both the magnitude and timing of flows entering the estuary and plume.

Historically, flow conditions in the estuary were determined by seasonal climate effects (such as precipitation) and hydrology. Since the early 1900s and to a larger degree since the 1960s, irrigation practices have reduced flows in the Columbia River. Water withdrawals as a result of agricultural irrigation and other water uses are estimated to have reduced flows of the Columbia River by 7 percent since the latter part of the nineteenth century (Jay and Kukulka 2003).

Other human activities that reduce flows are the result of upstream use of surface water and groundwater for commercial, industrial, municipal, domestic, and other purposes (National Research Council 2004).

Irrigation withdrawals of surface water account for approximately 96 percent of total water used, while municipal and other uses account for only 4 percent (National Research Council 2004). On the other hand, about 75 percent of all groundwater withdrawals support irrigation and the remaining 25 percent are used for other purposes (National Research Council 2004).

Limiting factors this threat contributes to: Flow-related estuary habitat and plume changes, flow-related changes in access to off-channel habitat, and reduced macrodetrital inputs.

Threat: Flow Regulation

The timing and magnitude of spring freshets have been drastically altered by management of the Columbia River hydrosystem (Fresh et al. 2005). Jay and Kukulka (2003) estimate that 26 percent of the overall reduction of freshet season flow since the late nineteenth century is attributable to flow regulation. Together with irrigation storage and withdrawal, flow regulation has increased fall and winter flows (winter flows have increased because of pre-release before the freshet season), and much of the seasonal timing of flows in the estuary can be attributed to flood control and hydroelectric operations.

Flow regulation is a function of the hydrosystem in the United States and Canada. The first hydroelectric facility in the lower Columbia Basin—the T.W. Sullivan Dam in Oregon City—was constructed in 1888. Since then, more than 450 dams have been built in the Columbia River basin (Columbia Basin Trust). These dams supply British Columbia with 50 percent of its electricity, while the American Northwest relies on hydropower for about two-thirds of its electricity (Columbia Basin Trust). Columbia River dams also provide flood control, enhance irrigation, and improve navigation.

The total active storage of water in the Columbia River Basin is 42 million acre-feet (Northwest Power and Conservation Council 2001), with dams in Canada accounting for about half of the total storage (Northwest Power and Conservation Council 2001). Major Canadian dams include the Duncan, Arrow, and Mica dams. Major U.S. hydroelectric facilities with significant storage include the Grand Coulee, Dworshak, Hungry Horse, and Libby dams. In addition, the U.S. Bureau of Reclamation owns and operates dozens of water storage dams in the Snake and Yakima rivers. The U.S. Army Corps of Engineers also operates many large flood control projects in the Willamette River.

Several recent changes in hydrosystem operations have been implemented to benefit salmonids throughout the basin. These include increasing flows by minimizing winter flood control drafts and reducing the amount of water needed to refill projects during the spring—measures that benefit spring juvenile salmonid migration in the mainstem Snake and Columbia rivers. Also, summer flows have been augmented to cool Snake River temperatures and assist migration of Snake River salmon and steelhead. Finally, a minimum flow has been administratively set from November through April to reduce the potential for dewatering of chum redds, primarily in Reach G in the estuary.

Limiting factors this threat contributes to: Flow-related estuary habitat and plume changes, flow-related changes in access to off-channel habitat, increased microdetrital inputs, and reduced macrodetrital inputs.

Sediment-Related Threats

Changes to seasonal flows, dredging, and the entrapment of sediment in reservoirs have altered those habitat-forming processes in the Columbia River estuary and plume that relate to sediment.

As described in Chapter 3, the transport of sediment is fundamental to habitat-forming processes in the estuary. Sediment helps create and maintain and promote wetlands, which are important to carbon cycling in the estuary and provide habitat for juvenile salmonids. Sediment also provides important minerals and nutrients that support food production in

the estuary and plume. And suspended sediments contribute to turbidity, which is important to salmonids because of the protection it provides from predators. Although the effects of impaired sediment processes on salmonids in the estuary are not fully understood, the magnitude of change and the key role that sediments play in habitat- and food-related processes are significant.

Entrapment of sediment in reservoirs, reduced downstream transport of sediment as a result of altered spring freshets, and dredging are the primary sediment-related threats to salmonids in the estuary. Ocean-type juvenile salmonids are affected by sediment-related changes in habitat in the estuary and by reduced turbidity (which can increase predation). Stream-type juveniles are affected by reduced turbidity in deeper waters in the estuary and plume.

Threat: Entrapment of Fine Sediment in Reservoirs

Reduction in water velocity as a result of upstream reservoirs has altered the transport of organic matter associated with fine sediments such as silt and clay. Fine sediments entering the estuary originate in the upper watersheds of the Snake River (Northwest Power and Conservation Council 2004). Reduced velocities behind upstream reservoirs cause reservoirs to act as a sink to fine sediments and likely reduce amounts delivered to the estuary (Northwest Power and Conservation Council 2004). Currently, organic matter associated with fine sediments supplies the majority of estuarine secondary productivity in the food web (Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004). Additionally, reductions in the quantity of fine sediments can increase water clarity and thus contribute to increased predation by piscivorous fish and birds.

Limiting factors this threat contributes to: Flow-related plume changes, sediment/nutrient-related estuary habitat changes, native birds, native fish, and exotic fish.

Threat: Impaired Transport of Coarse Sediment

Historically, the force of spring freshets moved sand down the river and into the estuary, where it formed shallow-water habitats that are vital for salmonids, particularly ocean types. Today, alterations to spring freshet flows have reduced sand discharge in the Columbia River estuary to 70 percent of nineteenth-century levels (Jay and Kukulka 2003). It is likely that the magnitude of change in sand transport affects habitat-forming processes and reduces turbidity, which results in increased predation in the estuary and plume environments.

Limiting factors this threat contributes to: Flow-related plume changes and sediment/nutrient-related estuary habitat changes.

Threat: Dredging

Dredging and the disposal of sand have been a major cause of estuarine habitat loss over the last century (Northwest Power and Conservation Council 2004). Currently, three times more sand is dredged from the estuary than is replenished by upstream sources (Northwest Power and Conservation Council 2004). In addition to causing habitat loss, dredging may have impaired sediment circulation in nearshore ocean areas and resulted in impacts to benthic organisms through disturbance. Still other impacts include the entrainment of crab, juvenile salmonids, sturgeon, and other fish and wildlife species.

Additional losses of vegetated wetlands in the Columbia River estuary are attributable to filling activities, with deposition of dredged materials accounting for most of the filling activities in the estuary (Fresh et al. 2005). Most dredged materials result from maintenance of the shipping channel. Dredged materials are disposed of in-water, along shorelines, or on upland sites; some dredged material disposal sites are shown in the reach maps in Appendix A. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year (Northwest Power and Conservation Council 2004). Significantly more dredged material has resulted from the U.S. Army Corps of Engineers' 43-foot channel deepening project. Dredge fill and diking activities have significantly reduced the availability of wetlands to the river, while placement of dredged material in several areas has increased nesting habitat for Caspian terns and cormorants.

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat and plume changes and native birds.

Structural Threats

The development of instream and over-water structures has altered circulation patterns, sediment deposition, sediment erosion, and the formation of habitats in the estuary. Examples of instream and over-water structures include jetties, pile dikes, tide gates, docks, breakwaters, bulkheads, revetments, seawalls, groins, and ramps (Williams and Thom 2001). Such structures create favorable conditions for predators such as northern pikeminnow and walleye, and they can reduce circulation in areas outside of the channel. Instream and over-water structures are found in all reaches of the estuary (for locations, see the reach maps presented in Appendix A).

Another structural threat is reservoirs associated with the hundreds of dams in the Columbia River basin. The construction and operation of these reservoirs has contributed to changes in the temperature of water entering the estuary.

Affected salmonids: Structural threats primarily affect ocean-type juvenile salmonids because of their longer residency time in the estuary and their wider use of off-channel habitats; however, scientists are now hypothesizing that stream-type juveniles forage outside of deeper channels in shallow-water habitats, where they may fall victim to predators that congregate near instream and over-water structures.

Threat: Pilings and Pile Dike Structures

Construction of the North and South jetties has altered sediment accretion and erosion processes near the mouth of the Columbia River. Sediment accretion in the marine littoral areas adjacent to the mouth has decreased the inflow of marine sediments into the estuary (Northwest Power and Conservation Council 2004), while the extensive use of pilings, pile dikes, and other structures to maintain the shipping channel has affected natural flow and sedimentation patterns. Pile dikes maintain the navigation channel by reducing the cross section of the river, increasing the velocity of the river within the channel, and at times slowing velocities immediately downstream of the dike. Development of the navigation channel has reduced flow to side channels and peripheral bays (Northwest Power and Conservation Council 2004). In addition, pile dikes and similar structures may create

conditions that increase predation on juvenile salmonids by northern pikeminnow and other piscivorous fish.

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat and plume changes and exotic fish.

Threat: Dikes and Filling

Dikes and filling activities have significantly altered the size and function of the Columbia River estuary. Since the early 1900s, dikes have been built to allow agricultural and residential uses (Fresh et al. 2005). Dikes are thought to have caused more habitat conversion in the estuary than any other human or natural factor (Thomas 1983, as reported in Northwest Power and Conservation Council 2004). The effects of diking on estuarine habitats are directly proportional to elevation, with the greatest impacts on the highest elevation estuarine habitats: forested wetlands, followed by tidal swamps and tidal wetlands. Diking-related impacts to these habitats have reduced their availability to juvenile salmon and steelhead (Thomas 1983, as reported in Northwest Power and Conservation Council 2004). Figure 4-3 shows the various zones found in typical estuaries. The emergent vegetation, diked marsh, shrub wetlands, and forested wetlands are the zones most affected by dike and filling practices (reprinted from Thom 2001). Diked areas and the historical floodplain in the Columbia River estuary are shown in the reach maps presented in Appendix A.

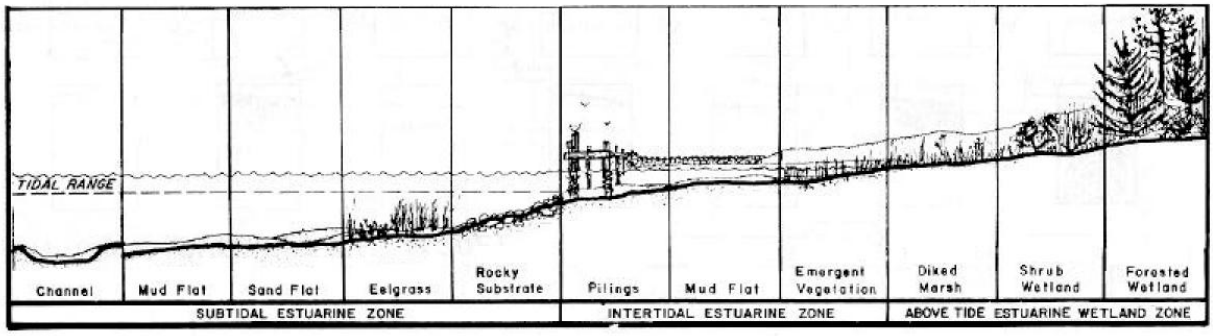


FIGURE 4-3
Subtidal, Intertidal, and Above-Tidal Estuarine Wetland Zones

Before development of the Columbia River hydrosystem and diking and filling, the estuary was dominated by macrodetrital inputs that originated from vegetated wetlands within the estuary. As a result of diking and filling practices and flow alterations (such as changes in the number and timing of spring freshets), emergent plant production in the estuary has decreased by 82 percent and macroalgae production has decreased by 15 percent (Northwest Power and Conservation Council 2004). The availability of insect prey for ocean-type salmonids has been reduced as vegetation has been removed via diking and filling activities and associated dike vegetation maintenance.

Limiting factors this threat contributes to: Reduced macrodetrital inputs, sediment/nutrient-related estuary habitat and plume changes, bankfull elevation increases, and exotic plants.

Threat: Reservoir-Related Temperature Changes

More than 450 dams have been built in the Columbia River basin (Columbia Basin Trust). The associated impoundment of water in upstream reservoirs increases the surface area of the Columbia River, allowing more solar heating of river water than occurs in free-flowing river stretches. This solar heating, combined with the reduced flows from upstream impoundments, has contributed to increased water temperatures in the Columbia River. Measurements at Bonneville Dam indicate that periods of increased temperatures are lasting longer than they did historically (National Research Council 2004). Currently, during summer months, average and maximum values of Columbia River water temperatures are often above 20° C (68°F), which approaches the upper limits of thermal tolerance for cold-water fishes such as salmon (National Research Council 2004). (For additional information on increases in water temperature in the lower Columbia River, see Figure 3-2 and the text that precedes the figure.)

The dynamics of reservoir-related temperature changes in the estuary are complicated and are affected by factors such as thermal inertia, which, among other things, contributes to delayed fall cooling and spring warming of downstream waters. Additional study is needed to better understand reservoir-related temperature changes and their effects on salmonids rearing in the estuary.

Limiting factors this threat contributes to: Water temperature.

Threat: Over-Water Structures

Over-water structures refer to docks, piers, transient moorage, log rafts, and other structures. These structures block sunlight, reduce flow, and trap sediments downstream of pilings (Kahler, Grassley, and Beauchamp 2000; Nightingale and Simenstad 2001). They also change circulation patterns and reduce edge habitats for ocean-type salmonids. Over-water structures contribute to predation on salmonids by altering habitat, creating microhabitats and favorable conditions for predators, especially the northern pikeminnow and non-native species such as small-mouth bass (Kahler, Grassley, and Beauchamp 2000; Nightingale and Simenstad 2001).

Although the actual square footage of over-water structures in the Columbia River estuary has never been inventoried, the structures themselves number in the thousands. Some research has occurred on the effects of breakwaters and over-water structures in the context of marinas. Salmon fry tend to concentrate in higher densities around these structures, thus increasing the risk of predation (Williams and Thom 2001).

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat changes, and exotic fish.

Food Web-Related Threats

As described in Chapter 3, changes in the estuarine food web can ripple through the ecosystem, altering energy pathways, feeding patterns, predator/prey relationships, and competition within and among species. As a result of increased nutrients, elevated water temperatures, slower passage of water through reservoirs, and entrapment of organic matter in reservoirs, concentrations of phytoplankton at the base of the food web in the

estuary are higher than they were historically. The introduction of exotic species such as shad may have accelerated the pace of ecological change in the estuary by permanently altering food webs. Food webs also have been altered by sediment transport, in that microdetrital food particles adhere to sediment suspended in the water column, making different food sources available to different species than was the case historically.

Affected salmonids: Both stream- and ocean-type salmonids are affected by energy-related threats—stream types primarily through increased predation in deep-water habitats and ocean types primarily through food web changes in the estuary. Ocean-type juveniles also are affected by reduced availability of insect prey as a result of the construction and maintenance of dikes.

Threat: Increased Phytoplankton Production

A reduction in macrodetrital inputs has shifted the food base in the estuary to phytoplankton produced in and imported from upstream reservoirs (Northwest Power and Conservation Council 2004), or produced as a result of augmented levels of nutrients from urban, industrial, and agricultural development. Phytoplankton support a food web that is less accessible to ocean-type salmonids occupying shallow edge habitats than the historical food web (Northwest Power and Conservation Council 2004). A shift from a generally animal-based salmonid diet to a generally plant-based diet may impair caloric inputs (Garman 1991; Cloe and Garman 1996; Nakano, Miyasaka, and Kuhara, 1999; Henschel, Mahsberg, and Stumpf 2001), and thus the fitness of salmonids that rely on estuarine rearing habitats to grow and prepare for ocean migration. The shift in food sources from a macrodetrital base to a microdetrital base provides different food sources than salmonids historically were accustomed to, in different places within the estuary, and this may favor different species. Because this area of study is immature in the estuary, it is difficult to establish which species benefit more than others.

Limiting factors this threat contributes to: Increased microdetrital inputs.

Threat: Altered Predator/Prey Relationships

Although predation has always occurred in the estuary ecosystem, the cumulative effect of altered flows, changes in sediment transport processes and food sources, introduced species, hatcheries, upstream habitat impacts, hydroelectric impacts, and contaminants have recast estuary and plume environments such that predator/prey relationships have changed significantly. As a result, significant numbers of salmon are lost to fish, avian, and marine mammal predators during migration and residency in the estuary (Northwest Power and Conservation Council 2004). Fish predators include northern pikeminnow, walleye, smallmouth bass, and catfish; avian predators include Caspian terns, double-crested cormorants, and gull species; and marine mammal predators include Steller and California sea lions and harbor seals.

Degraded conditions (loss of habitat and altered food web) in the Columbia River estuary and the timing of large hatchery releases have increased the likelihood that mortality from competition may occur under some circumstances (Northwest Power and Conservation Council 2004). Mortality from intra-species competition has been documented in the Skagit River estuary (Beamer et al. 2005), and there is speculation that it may be a factor in the Columbia River as well (Northwest Power and Conservation Council 2004). If inter-species

competition is occurring, it is likely to have the greatest impact on ocean-type salmonids because of their longer residence time in the estuary (Northwest Power and Conservation Council 2004). If density dependence is affecting stream-type juveniles, it likely happens in the plume.

As the result of human alterations of the estuary environment, native species such as Caspian terns and double-crested cormorants have significantly increased in number, with measurable impacts on stream-type salmonids (Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers 2004). These increases in population in the Columbia River estuary are attributed to the deposition of dredged materials in the estuary that represent high-quality habitat for the birds (Bottom et al. 2005) and predation opportunities for cormorants created through the placement of pilings, pile dikes, and other structures. The loss of habitat elsewhere has contributed to terns and cormorants effectively relocating to the Columbia River estuary, with the populations there now representing the largest nesting colonies in the world.

Similarly, the new microdetritus-based food web in the estuary has benefited zooplanktivores, including American shad (an introduced species) (Northwest Power and Conservation Council 2004). Although shad do not appear to be in direct competition with salmonids, their biomass alone—more than 4 million returning adults a year—represents a threat to trophic relationships in the Columbia River. Future increases in water temperatures as a result of climate change may improve conditions for shad in the Columbia River Basin and lead to their continued expansion (Independent Scientific Advisory Board 2008). Other exotic fish species such as introduced walleye and catfish also have been able to capitalize on degraded conditions in the upper reaches of the estuary and altered food web dynamics through predation and competition for food resources (Northwest Power and Conservation Council 2004).

Pinniped predation on adult spring Chinook and winter steelhead continues to increase. On the West Coast the total abundance of California sea lions is approximately 250,000; Stellar sea lions total about 31,000, and Pacific harbor seals total about 25,000 (Griffin 2006). Each spring about 1,000 Stellar sea lions, 3,000 Pacific harbor seals, and 800 California sea lions take up residence in the lower estuary (Griffin 2006). About 1,000 sea lions and harbor seals enter the freshwater portion of the estuary; of these, approximately 80 animals (primarily California sea lions) congregate at Bonneville Dam. The U.S. Army Corps of Engineers' estimates that annual adult mortality at Bonneville Dam because of pinnipeds (primarily California sea lions) ranged from 0.4 percent (2002) to 4.2 percent (2007) during the study period ending in 2010 (U.S. Army Corps of Engineers 2010).[1] Other, radio telemetry-based studies suggest that annual pinniped predation on spring Chinook and winter steelhead at Bonneville Dam may be as high as 8.5 percent and 20 percent, respectively (NMFS 2008b, Appendix G). There is a need for better estimates of the mortality caused by pinnipeds throughout the estuary and plume. Unsubstantiated estimates suggest a mortality rate of 10 percent of the entire adult spring Chinook and steelhead runs in a given year.

Non-native plant species have altered habitat and food webs in the Columbia River estuary. The rate of intentional and unintentional introductions has been increasing over the past 100

[1] Estimated consumption of adult salmonids ranged from a low of 1,010 in 2002 to a high of 6,081 in 2010; the percent of run consumed varied among reporting years in part because of changes in run size.

years, mostly as a result of horticultural practices and the increase in travel and commerce in the Columbia River. Four of those species—purple loosestrife, Eurasian water milfoil, parrot feather, and Brazilian elodea—are of particular concern. Each of these species, in its own way, alters habitat and food webs in the estuary. Purple loosestrife, for example, adapts easily to environmental changes and expands its ranges quickly. The primary ecological effect of purple loosestrife is that it disrupts wetland ecosystems by displacing native plants. Eventually, animals that rely on native flora for food, nesting, or cover also are displaced (Northwest Power and Conservation Council 2004).

Limiting factors this threat contributes to: Native birds, native fish, native pinnipeds, introduced invertebrates, exotic fish, and exotic plants.

Threat: Ship Ballast Practices

Ship ballast practices have been responsible for the introduction of at least 21 exotic species in the Columbia River estuary (Sytsma et al. 2004). When ships release ballast water, non-indigenous species can enter receiving waters. Most of the non-indigenous species in the estuary have originated from Asia (Sytsma et al. 2004). Populations of non-native copepods have established themselves in Reaches A and B (Youngs Bay, Cathlamet Bay, and Grays Bay), and the New Zealand mudsnail has colonized other estuary reaches. The Asian bivalve *Corbicula fluminea* has expanded its range in the estuary, with densities of 10,000 per m^2 being recorded in Cathlamet Bay; however, densities of 100 to 3,000 m^2 are more common (Northwest Power and Conservation Council 2004). These and other non-indigenous invaders disrupt food webs and out-compete juvenile salmonids' native food sources.

An emerging source of concern regarding ship ballast practices is the potential entrainment of juvenile salmonids when large ships take on ballast water as they leave ports unloaded. This issue is being evaluated in relevant Endangered Species Act (ESA) Section 7 consultations (Tortorici 2008).

Limiting factors this threat contributes to: Introduced invertebrates.

Water Quality-Related Threats

The release of toxic contaminants, nutrient loading, and reduced dissolved oxygen have altered the quality of salmonid habitats in the Columbia River estuary. Currently the estuary receives toxic contaminants or nutrients from more than 100 point sources and numerous non-point sources, such as surface and stormwater runoff from urban and agricultural areas (Fuhrer et al. 1996 as referenced in Fresh et al. 2005). In most areas, nonpoint sources such as agricultural, urban, industrial, and timber harvest practices contribute greater nutrient loads than point sources do (Wise et al. 2007). The Snake, Yakima, Deschutes, and Willamette rivers contribute most of the nutrient loads discharged to the Columbia River. Nutrient yields (loads normalized for basin size) are generally greater in basins west of the Cascade Range and are correlated with precipitation and point-source loads (Wise et al. 2007).

Threat: Agricultural Practices

The health of an aquatic ecosystem is substantially affected by agricultural, urban, and industrial practices and wastewater discharge (National Research Council 2004). Specific threats include increased nutrients (nitrogen and phosphorus), sediment, and organic and trace metals (National Research Council 2004). For example, Wise et al. (2007) found a significant correlation between total nitrogen yields in basins west of the Cascades and fertilizer and manure loads. Increased nutrient loads from anthropogenic sources can lead to increased phytoplankton concentrations, decreased water clarity, and depressed dissolved oxygen levels, especially in areas with longer residence times and warmer water temperatures. DDT, other banned pesticides that have persisted in the environment, and pesticides in current use are entering the estuary from agricultural runoff, some of which originates outside the lower Columbia River basin. The middle and upper Columbia are primary sources of DDT and other organochlorine pesticides in the estuary, as are tributaries such as the Yakima and Willamette rivers (Clark et al. 1998, Williamson et al. 1998, Hinck et al. 2006, Johnson and Norton 2005, McCarthy and Gale 2001 as cited in Lower Columbia River Estuary Partnership 2007). A 2007 study confirmed the presence of the pesticides atrazine, simazine, metolachlor, EPTC, DCPA, and diuron at sites throughout the estuary, often in combination (Lower Columbia River Estuary Partnership 2007). The timing of detections suggests that precipitation events play an important role in transporting pesticides to the Willamette River, which is a primary contributor of both agricultural and urban/industrial contaminants to the Columbia River estuary.

The U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN) program also reports detection of a wide range of commonly used pesticides at sampling sites near Bonneville Dam and at the confluence of the Willamette and Columbia rivers (Fresh et al. 2005). Detected pesticides include simazine, atrazine, chlorpyrifos, metolachlor, diazinon, and carbaryl. Arsenic and trace metals such as copper, iron, and manganese also have been detected. Although trace metals occur naturally, they also are introduced through human activities, such as the use of lead arsenate as an insecticide for apples (Fresh et al. 2005). Water-soluble contaminants, trace metals, and chlorinated compounds have been detected in the estuary (Fresh et al. 2005), and DDT, PCBs, dioxins, and metals have been detected at elevated levels in tissue from fish in the estuary (Northwest Power and Conservation Council 2004).

Limiting factors this threat contributes to: Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.

Threat: Urban and Industrial Practices

The Columbia River downstream of Bonneville Dam is the most urbanized stretch in the entire basin. The area has more than 100 point sources that are known to discharge directly into the Columbia River estuary; these include chemical plants, pulp and paper mills, hydroelectric facilities, municipal wastewater treatment plants, and seafood processors (Fuhrer et al. 1996 as cited in Lower Columbia River Estuary Partnership 2007). Potential nonpoint sources include hazardous waste sites, landfills, marinas and moorages, and overland surface runoff that transports nutrients, sediment, PAHs, metals, and pesticides from streets, yards, and industries.

The largest sources of effluent in this area are the Portland and Vancouver sewage treatment plants (Fresh et al. 2005), with Portland's wastewater treatment facility being the largest point-source discharger in the Columbia Basin (Wise et al. 2007). The annual nutrient loads from this facility equal approximately 2 to 3 percent of the annual in-stream nutrient loads at the Beaver Army Terminal water quality sampling site, downstream of Longview, Washington (Wise et al 2007). Contaminants also are transported to the estuary from areas above Bonneville Dam, such as the Deschutes, Yakima, and Snake rivers. These rivers, together with the Willamette, contribute most of the nutrient loads discharged to the Columbia River (Wise et al. 2007).

An intensive study of sediments in Portland Harbor (the stretch of the Willamette River from Sauvie Island to Swan Island) has uncovered pesticides, PCBs, and other toxic chemicals. In general, studies have shown that PCB and PAH concentrations in salmon and their prey in the estuary are comparable to those in organisms in other moderately to highly urbanized areas (Fresh et al. 2005, Lower Columbia River Estuary Partnership 2007, Johnson et al. 2007b). Industrial contaminants such as PAHs have been detected in sediments from the lower Willamette River in Portland at levels that exceed state or Federal sediment quality guidelines. The U.S. Environmental Protection Agency identified PCB and DDT hot spots within the estuary, including near Longview, West Sand Island, the Astoria Bridge, and Vancouver (Fresh et al. 2005). Studies in the 1990s found that sediment contamination was highest near urban and industrial areas, with concentrations in excess of levels of concern for DDE (a breakdown product of DDT), PCBs, dioxins and furans, and PAHs (Tetra Tech 1996). Current studies find higher levels of flame retardants (PBDEs), PCBs, and DDT on bed sediment collected near Portland than in sediment collected from other sites in the estuary (Jones et al. 2008).

In addition, emerging contaminants associated with urban development are beginning to be detected in the Columbia River estuary. These include PBDE flame retardants, which have been found in juvenile salmon tissue, their stomach contents, the water column, and on suspended sediment at sites throughout the estuary (Lower Columbia River Estuary Partnership 2007). Caffeine, human and veterinary antibiotics, synthetic musk, and the plasticizer bisphenol A have also been detected in the water of the estuary (Lower Columbia River Estuary Partnership 2007). Although the effects of these compounds are not yet well understood, some of them are suspected hormone disruptors, and juvenile salmon collected from the estuary show evidence of exposure to estrogenic compounds (Lower Columbia River Estuary Partnership 2007). This could be the result of emerging contaminants or more familiar toxic contaminants in the estuary, such as certain pesticides.

Limiting factors this threat contributes to: Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.

Other Threats

Threat: Riparian Practices

Riparian practices along the estuary mainstem and in tributaries throughout the Columbia River basin have contributed to increases in water temperature in the estuary by changing hydrology and removing riparian habitats (National Research Council 2004) that—among other ecological functions—provide insects and macrodetrital inputs to the food web.

Problematic practices include shoreline modifications, timber harvest, certain agricultural activities within riparian zones, and residential, commercial, and industrial land uses. These activities increase water temperatures, alter hydrology and macrodetrital inputs, and in some cases modify shoreline habitats used by salmonids, especially ocean types (Lower Columbia Fish Recovery Board 2004).

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat changes, reduced macrodetrital inputs, water temperature, and exotic plants.

Threat: Ship Wakes

Ships traveling through the Columbia River estuary produce waves and an uprush which, under certain circumstances, causes juvenile salmonids and other fish to become stranded on shore (Bauersfeld 1977). Although Bauersfeld concluded that ship wake stranding was a significant cause of mortality in ocean-type Chinook salmon and other species, other studies have not confirmed the magnitude of this threat. As a part of the U.S. Army Corps of Engineers' channel deepening project, a study is under way that may help characterize the magnitude of ship wake stranding. The purpose of the study is to document ship wake stranding before and after channel deepening. The first half of the study, published in February 2006, documented stranding events at three test sites. The second part of the study will begin after dredging is completed (Pearson et al. 2006). These results should be useful as partial basis for Light Detection and Ranging (LIDAR) analysis and extrapolation of test site mortality throughout the estuary for similar habitat types. Early in 2008, the Port of Vancouver enlisted Entrix, Inc., to perform a spatial analysis of beach susceptibility for the stranding of juvenile salmonids by ship wakes (Pearson 2008). The study examined wave characteristics and the geomorphology of the lower river but did not examine nearshore fish density. The purpose of the study was to estimate the number of miles of shoreline that exhibit traits expected to potentially cause stranding. The study concluded that approximately 33 miles of shoreline between the mouth of the river and the city of Vancouver have shoreline characteristics consistent with stranding (Pearson 2008).

Limiting factors this threat contributes to: Stranding.

Prioritization of Threats

This estuary recovery module establishes priorities for threats by linking them to pertinent limiting factors and estimating their relative contribution to those limiting factors. The threats identified above are well supported in a wide variety of literature sources, including Fresh et al. (2005), Bottom et al. (2005), the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" (Northwest Power and Conservation Council 2004), and a variety of more topic-specific primary literature sources.[2] The prioritization of threats, though, is not nearly as well supported, partly because of the limited understanding of how threats contribute to limiting factors and to what degree salmon and steelhead are affected by a given limiting factor. While it is attractive to assume that additional study will fully answer these questions, the biological response to environmental conditions will always be difficult to model because of the tremendous complexities of the physical, biological, and

[2] As with the limiting factors, most of the threats identified in this chapter are not supported by data at the reach or sub-reach scale.

ecological interplay that occurs in the environment. On the other hand, new interest in the estuary and its role in the recovery of listed species in the Columbia River has generated better understanding, and it is likely that uncertainty surrounding threats and limiting factors will continue to lessen.

Table 4-1 demonstrates the relationship between limiting factors and threats by showing which threats are causing which limiting factors and estimating the contribution of each threat to each limiting factor. The presumed relative contribution of a threat to each limiting factor is indicated by the primary, secondary, or tertiary designation. The contribution of each threat to its associated limiting factor(s) is multiplied by the relative importance of that limiting factor to salmonids to yield the threat index score. This score expresses the relative priority of the threat in question. (The relative importance of limiting factors is taken from Table 3-2.)

PC Trask & Associates, Inc., developed the initial threat contribution scores for Table 4-1 by reviewing the extent to which the three main literature sources—and other sources—described relationships between limiting factors and threats or evaluated the contribution of multiple threats to a single limiting factor. Although literature sources were useful in making connections between threats and limiting factors, in many cases the literature did not separate limiting factors from threats or did not attempt to identify and rank the full scope of threats that might be contributing to a particular limiting factor. In nearly all cases, authors discussed cause-and-effect relationships in qualitative language. In some cases, authors described quantitative relationships, as in the relationship between flow regulation and sediment transport. Only a handful of sources estimated priorities for threats.

To supplement information gleaned from the literature, the author talked with regional experts (see Acknowledgements) to identify potential threat contributions not described in the literature. The author also refined the initial scores based on review and input by NMFS Northwest Fisheries Science Center, NMFS Northwest Regional office, Lower Columbia River Estuary Partnership, and Lower Columbia Fish Recovery Board staff. The author, in consultation with staff from the Lower Columbia River Estuary Partnership and NMFS, also made minor adjustments to the scores in response to comments received during the public review period.

TABLE 4-1
Linkages Between Limiting Factors and Threats to Ocean- and Stream-Type Salmonids

Limiting Factor	Threat	Limiting Factor Priority & Numerical Score[a]	Contribution of Threat to Limiting Factor, & Numerical Score[b]	Threat Index[c]
Flow-related estuary habitat changes	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15
Flow-related changes in access to off-channel habitat	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15
Flow-related plume changes	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15

Limiting Factor	Threat	Limiting Factor Priority & Numerical Score[a]	Contribution of Threat to Limiting Factor, & Numerical Score[b]	Threat Index[c]
	Impaired transport of coarse sediment	Top (5)	Secondary (2)	10
	Entrapment of fine sediment in reservoirs	Top (5)	Tertiary (1)	5
Water temperature	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Reservoir-related temperature changes	Top (5)	Secondary (2)	10
	Riparian practices	Top (5)	Secondary (2)	10
Reduced macrodetrital inputs	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Riparian practices	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15
	Dikes and filling	Top (5)	Primary (3)	15
Sediment/nutrient-related estuary habitat changes	Impaired transport of coarse sediment	High (4)	Primary (3)	12
	Entrapment of fine sediment in reservoirs	High (4)	Secondary (2)	8
	Dredging	High (4)	Secondary (2)	8
	Pilings and pile dike structures	High (4)	Primary (3)	12
	Dikes and filling	High (4)	Primary (3)	12
	Over-water structures	High (4)	Tertiary (1)	4
	Riparian practices	High (4)	Tertiary (1)	4
Bankfull elevation changes	Dikes and filling	High (4)	Primary (3)	12
Native birds	Entrapment of fine sediment in reservoirs	High (4)	Tertiary (1)	4
	Dredging	High (4)	Secondary (2)	8
	Altered predator/prey relationships	High (4)	Primary (3)	12
Native pinnipeds	Altered predator/prey relationships	High (4)	Primary (3)	12
Non-bioaccumulative toxicity	Agricultural practices	High (4)	Primary (3)	12
	Urban and industrial practices	High (4)	Primary (3)	12
Native fish	Entrapment of fine sediment in reservoirs	Medium (3)	Tertiary (1)	3
	Altered predator/prey relationships	Medium (3)	Primary (3)	9
Bioaccumulation toxicity	Agricultural practices	Medium (3)	Primary (3)	9
	Urban and industrial practices	Medium (3)	Primary (3)	9
Sediment/nutrient-related plume changes	Dredging	Low (2)	Primary (3)	6
	Pilings and pile dike structures	Low (2)	Secondary (2)	4
	Dikes and filling	Low (2)	Secondary (2)	4
Stranding	Ship wakes	Low (2)	Primary (3)	6
Increased microdetrital inputs	Agricultural Practices	Low (2)	Secondary (2)	4
	Urban and industrial practices	Low (2)	Secondary (2)	4
	Increased phytoplankton production	Low (2)	Primary (3)	6
	Flow regulation	Low (2)	Tertiary (1)	2

Limiting Factor	Threat	Limiting Factor Priority & Numerical Score[a]	Contribution of Threat to Limiting Factor, & Numerical Score[b]	Threat Index[c]
Exotic fish	Entrapment of fine sediment in reservoirs	Lowest (1)	Tertiary (1)	1
	Over-water structures	Lowest (1)	Secondary (2)	2
	Pilings and pile dike structures	Lowest (1)	Secondary (2)	2
	Altered predator/prey relationships	Lowest (1)	Primary (3)	3
Introduced invertebrates	Altered predator/prey relationships	Lowest (1)	Tertiary (1)	1
	Ship ballast practices	Lowest (1)	Primary (3)	3
Exotic plants	Dikes and filling	Lowest (1)	Primary (3)	3
	Riparian practices	Lowest (1)	Secondary (2)	2
	Altered predator/prey relationships	Lowest (1)	Primary (3)	3

[a] From Table 3-2.

[b] Indicates how important the threat is in perpetuating the limiting factor:

3 = Threat is a primary cause of the limiting factor. Addressing this threat would significantly improve salmonid performance.

2 = Threat is a secondary cause of the limiting factor. Addressing this threat would improve performance.

1 = Threat is a tertiary cause of the limiting factor. Addressing this threat would benefit performance, but by itself would result in only minor improvement.

[c] Product of the numerical scores for the limiting factor priority and the threat's contribution to the limiting factor. A high threat index score means that the threat is a major contributor to one or more significant limiting factors. A low threat index score means the threat is a small contributor to a minor limiting factor.

Table 4-2 organizes threats by their threat index score, in descending order. However, the state of the science is such that the differentiation of threat priorities in Tables 4-1 and 4-2 should be viewed as reasonable guidance and a set of working hypotheses to be tested and refined through research and evaluation. Given uncertainties about estuarine ecosystems and how they function, some threats that are ranked relatively low in Table 4-2 may eventually prove to have large impacts to the estuary. For example, it is difficult to dispute the importance of flow regulation compared to ship ballast practices. But it is possible that the effects of exotic invertebrates introduced to the estuary through ship ballast practices will significantly degrade the overall health of the estuary ecosystem over time and that this threat will move up in the priority ranking. As another consideration, Tables 4-1 and 4-2 reflect the prioritization of threats across the entire estuary; within each reach, threats could be prioritized differently. A reach-scale analysis of limiting factors and threats was beyond the scope of this document and, in some cases, beyond the limits of currently available science. But such an analysis would be useful as additional scientific information becomes available.

TABLE 4-2
Prioritization of Threats to Ocean- and Stream-Type Salmonids

Threat	Threat Index*	Threat Priority
Flow regulation	15	
Dikes and filling	15	
Altered predator/prey relationships	12	
Urban and industrial practices	12	HIGH
Agricultural practices	12	
Impaired transport of coarse sediment	12	
Pilings and pile dike structures	12	
Reservoir-related temperature changes	10	
Riparian practices	10	
Climate cycles and global climate change	10	
Water withdrawal	10	
Dredging	8	
Entrapment of fine sediment in reservoirs	8	
Ship wakes	6	
Increased phytoplankton production	6	LOW
Over-water structures	4	
Ship ballast practices	3	

* From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

Summary

Chapter 4 provides information on the underlying causes of the factors that influence the viability of ocean- and stream-type ESUs during their residency and migration in the estuary. Analysis of threats is challenging because a single threat often contributes to multiple limiting factors and may originate miles upstream from the estuary. In Chapter 4, threats were identified, described, linked to limiting factors, and prioritized. Chapter 5 turns to management actions, identifying actions that will address threats and thus help reduce risks to the 13 ESA-listed ESUs using the Columbia River estuary.

CHAPTER 5

Management Actions

Chapters 3 and 4 of this recovery plan module identify factors that currently limit salmonids' biological performance in the estuary and the threats that contribute to those limiting factors. Chapter 5 presents 23 management actions that, together, address the range of threats salmonids in the estuary face, from altered habitat-forming processes to physical structures in the estuary, changes in the food web, and poor water quality. If implemented, the actions presented in this chapter would reduce the impacts of threats to salmonids during their migration and residency in the estuary and plume.

In addition to identifying the management actions, Chapter 5 evaluates them in terms of constraints to implementation, potential improvement in salmonid survival, and cost. More specifically, the chapter discusses each management action's potential benefits and implementation constraints, hypothesizes how benefits could translate into increased survival of salmonids, breaks each action into component projects, and estimates the cost of each project, and thus of each action. Also included is a list of actions that would address threats to salmonids in the estuary but that would need to be implemented outside the estuary, either in estuary tributaries or in upstream areas of the Columbia River basin.

As in other chapters of this recovery plan module, the analysis in Chapter 5 does not fully capture the subtleties of the ecological interactions that influence salmonid survival. Despite continuing research, many aspects of the salmonid life cycle are poorly understood, in part because of the sheer complexity of the ecosystems that salmonids transition into and out of during their lives. The actual relationships among threats and management actions are far more intricate than what is described here. Additionally, given the limits in scientific understanding, there is a degree of uncertainty at each step of the analysis in this chapter. Yet the categories, ratings, and associations presented here are useful tools for discussing complex ecological relationships and comparing possible outcomes of different management actions.

Identification of Management Actions

For the purposes of this recovery plan module, a management action is any action that has the potential to reduce the impact of human-caused or naturally occurring threats to salmonids while they migrate or rear in the estuary and plume. PC Trask & Associates, Inc., identified management actions using available literature and input from area experts (see Acknowledgements). Key documents used to identify management actions are the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" (Northwest Power and Conservation Council 2004) and its supplement; *Role of the Estuary in the Recovery of Columbia River Salmon and Steelhead (*Fresh et al. 2005); *Salmon at River's End* (Bottom et al. 2005); and the *2004 FCRPS Biological Opinion on Remand* (National Marine Fisheries Service 2004). Table 5-1 lists threats to salmonids in the estuary and plume and management actions that would address those threats; this information is organized by topic and does not reflect the priority of either threats or management actions.

TABLE 5-1
Management Actions to Address Threats

	Threat	Management Action
Flow-related threats	Climate cycles and global climate change[2]	**CRE[1]-1:** Protect intact riparian areas in the estuary and restore riparian areas that are degraded.[2] **CRE-2:** Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.[2] **CRE-3:** Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.[2]
	Water withdrawal	***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries*
	Flow regulation	**CRE-4**: Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume. ***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.*
Sediment-related threats	Entrapment of fine sediment in reservoirs	**CRE-5:** Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.
	Impaired transport of coarse sediment	**CRE-6:** Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially. **CRE-8:** Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health. ***CRE-4:*** *Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.*
	Dredging	**CRE-7:** Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.
Structural threats	Pilings and pile dike structures	***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Dikes and filling	**CRE-9:** Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat. **CRE-10:** Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.
	Reservoir-related temperature changes	***CRE-2:*** *Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.*
	Over-water structures	**CRE-11:** Reduce the square footage of over-water structures in the estuary.

	Threat	Management Action
Food web-related threats	Increased phytoplankton production	***CRE-10:*** *Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.*
	Altered predator/prey relationships	**CRE-13:** Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids. **CRE-14:** Identify and implement actions to reduce salmonid predation by pinnipeds. **CRE-15:** Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants. **CRE-16:** Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island. **CRE-17:** Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations. **CRE-18:** Reduce the abundance of shad in the estuary. ***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Ship ballast practices	**CRE-19:** Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations ***CRE-7:*** *Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.*
Water quality-related threats	Agricultural practices	**CRE-20:** Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
	Urban and industrial practices	**CRE-21:** Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants. **CRE-22:** Restore or mitigate contaminated sites. **CRE-23:** Implement stormwater best management practices in cities and towns.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
Other threats	Riparian practices	***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.*
	Ship wakes	**CRE-12:** Reduce the effects of vessel wake stranding in the estuary.

[1] CRE = Columbia River estuary.

[2] Study of the impacts of global climate change is an evolving field, and additional research is needed to understand the phenomenon's likely effects on estuarine habitats and processes with specificity. At this time, the Independent Scientific Advisory Board of the Northwest Power and Conservation Council expects that the regional effects of global climate change in the next century will include more precipitation falling as rain rather than snow, reduced snow pack, and late-summer/early-fall stream flows, and associated rises in stream temperature (Independent Scientific Advisory Board 2007). The climate-related management actions in Table 5-1 reflect these expected impacts. Although the management actions clearly would not change the threat of global climate change itself, they have the potential to lessen its impact on salmonids in the estuary. Even if climate cycles and global climate change have effects different from those assumed in this document, the management actions that Table 5-1 associates with climate would provide benefits to salmonids by addressing other threats, such as water withdrawal, urban and industrial practices, and reservoir heating. All three of the management actions associated with climate in Table 5-1 are associated with other threats listed in Table 5-1.

[3] Unless otherwise noted, the term *best management practices* is used in this document to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

Note: Italics indicate an action's second occurrence in the table, in connection with a different threat.

Given the complexity of the riverine, estuarine, and marine ecosystems that salmon use during their lives, the actual relationships among threats and management actions are more complicated than Table 5-1 suggests. For example, several of the management actions in Table 5-1 are associated with more than one threat (italics indicate an action's second occurrence in the table). This illustrates the complex interplay of ecological processes in the estuary, particularly processes related to flow, sediment, the food web, and water quality, all of which influence salmon survival. Later in this chapter actions are described and analyzed discretely. Some actions are interrelated, both in the problems they attempt to solve and their probable effects. As an example, CRE-2 through CRE-5 (reducing the effects of reservoir heating, protecting/enhancing instream flows influenced by withdrawals and other water management actions in tributaries, adjusting flow timing and magnitude, and addressing entrapment of fine sediments in reservoir) all deal with reservoir and hydrosystem operations. If implemented together, these actions could act in concert to significantly improve water temperature and sediment delivery in the estuary, potentially providing greater benefits through synergistic action than if they were implemented singly. The potential for synergistic effects of management actions is discussed in more detail in Chapter 7.

The estuary recovery module also identifies specific monitoring, research, and evaluation activities appropriate to the 23 management actions. These activities will provide crucial information on the effectiveness of actions that are implemented in the estuary, associated changes in the ecology of the estuary, and scientific uncertainties that affect implementation of the actions. Monitoring, research, and evaluation activities are presented in Chapter 6. Some of these activities are part of the *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008), while others are specific to the management actions in this recovery plan module.

Other Recommended Management Actions

In many ways, conditions in the estuary are the sum of ecological stressors that exist throughout the Columbia River basin. Although some threats to salmonids in the estuary originate exclusively in the estuary itself (Caspian tern predation is one example), others are the result of activities in estuary tributaries or in upstream areas; examples of such threats are riparian practices and upstream water withdrawals that reduce stream flow in the estuary. Still other threats, such as land use practices that contribute contaminants to the river, originate in all three areas—estuary, estuary tributaries, and upstream. Because of the geographic scope of these threats, fully addressing them will require effort not just in the estuary but throughout the basin.

When it comes to management actions, though, the geographic scope of this estuary recovery plan module is limited. For the most part the module focuses on management actions that can be implemented within the estuary itself and that will address threats that either originate exclusively within the estuary itself or have a significant in-estuary component. The assumption is that threats originating from outside the estuary are affecting local conditions in tributary and upstream areas and that actions to address these threats will be included in recovery plans being developed for upstream salmonid populations.

Even so, the analysis in Chapters 3 and 4 of this recovery plan module and a review of contemporary literature yielded six management actions that would directly affect threats to salmonids in the estuary yet would need to be implemented almost exclusively outside of the estuary or are otherwise beyond the scope of this document:

- Implement hatchery actions as appropriate throughout the Columbia River basin to reduce the threat of density-dependent mortality as a direct result of ecological interactions (disease, predation, or competition for food or space) between hatchery and wild salmonid juveniles using reduced and/or impaired lower river habitats. The magnitude of the ecological interactions as a function of the cumulative effects of large hatchery releases on natural-origin salmonids, both spatially and temporally, is currently an important scientific uncertainty.
- Upgrade up-river irrigation structures to reduce evaporation and conveyance losses and improve estuary instream flows.
- Implement public and private best management and water system conservation practices to maximize the quantity and quality of instream flows entering the estuary.
- Incorporate water availability analysis in land use planning activities to ensure efficient use of water, improve tributary flows, and reduce stream temperatures.
- Protect and restore riparian areas in tributaries to provide shade and future wood sources.
- Reduce inputs of toxic contaminants originating from upstream tributary and mainstem sources.

Because these six actions are outside the geographic scope of the estuary recovery plan module, they are not analyzed in this chapter. Nevertheless, implementation of these six out-of-estuary actions is important to improving the survival of salmonids in the estuary, so it is recommended that the actions be included in recovery plans being developed for upstream areas of the Columbia River basin.

One factor that is beyond the geographic scope of the estuary recovery plan module but is addressed in the module in a limited manner is hydrosystem operations, which affect water temperature, sediment transport, and various other habitat-forming processes and conditions in the estuary. Although actual operation of the hydrosystem occurs outside the estuary, the system's effects are considered in the module because they are such significant determinants of habitat conditions for juvenile salmonids in the estuary. Also, unlike the recommended out-of-estuary actions listed above, hydrosystem operations that affect estuarine habitat are unlikely to be addressed in recovery plans being developed for upstream areas of the Columbia River basin. For these reasons, the estuary recovery plan module includes two management actions (CRE-2 and CRE-4) that focus specifically on hydrosystem operations.

The recommendation of out-of-estuary actions to improve survival in the estuary is another reflection of the interconnectedness of the various ecosystems salmonids use during their life cycles, the power of the river as a connector, and how the effects of problematic upstream activities are manifested—and sometimes magnified—in the estuary.

Evaluation of Management Actions: Constraints to Implementation

Constraints to implementation are a key factor in evaluating management actions and their likely impacts on salmonids. No management action can benefit salmonids if it cannot be implemented, and in many cases the degree of benefit corresponds to the degree of implementation. For this reason, the 23 management actions identified above are evaluated in terms of the constraints to their implementation, which yields information about the actions' likely outcomes and starts to provide a basis for comparing the probable effectiveness of different actions.

PC Trask & Associates, Inc., performed an initial rating of management action constraints by qualitatively estimating the degree of difficulty in implementing each action, taking into account social, political, and technical factors, including the probable cost of implementation. Staff at the Lower Columbia River Estuary Partnership, NMFS Northwest Fisheries Science Center, NMFS Northwest Regional Office, and Lower Columbia Fish Recovery Board provided input into this process. PC Trask & Associates, Inc., and NMFS also revised some constraint scores in response to the *Federal Register* public comment process. Because the scientific literature generally falls short of prescribing discrete actions to address threats and is even less robust when it comes to evaluating constraints to implementation, the reader should view specific ratings as a qualitative estimate only, but one that is useful in comparing relative implementation constraints across the 23 management actions.

For each management action, Table 5-2 summarizes the primary threat and limiting factors that the action addresses and expresses the significance of those threats and limiting factors in terms of a threat index. (The threat index indicates whether the threat is a major contributor to a significant limiting factor or a minor contributor to a minor limiting factor. The index is useful in distinguishing those actions that, even if they were successful, would affect a relatively small number of fish from those actions that, even if they were only partially implemented or partially successful, would have more profound benefits because they would affect a larger number of fish.) Table 5-2 also provides a score for the potential benefit to salmonids in the estuary if implementation of the action were completely unconstrained, plus a brief rationale for the score.

Assigning a score for potential benefit with unconstrained implementation is just the first step in evaluating management actions. In fact, decisions about management actions will be made within a complex social and political context that includes a wide variety of interests, and it is likely that many of the actions will not be able to be implemented fully because of various technical, financial, political, or social obstacles. To address this issue, Table 5-2 assigns an implementation constraints score to each management action and briefly explains how implementation of the action could be constrained by various factors. It then gives a score that represents the potential benefits of the action if implementation of the action is constrained. By design, the estuary recovery module takes a relatively optimistic view about what is possible in terms of reducing the constraints to implementation of management actions. This means that even the score in Table 5-2 for constrained implementation of an action may represent a higher degree of implementation than is likely to actually occur. However, some constraints may be reduced over time, such as through technology

advances or changes in economic sectors; as a result, some actions may have greater potential for implementation than is represented in this recovery plan module.

The table concludes with a score for potential benefit of each action assuming that implementation of the action is constrained. This score is an attempt to identify more realistically what the results of an action would be given the social, political, and financial climate in which management actions will be decided on, but it also assumes that considerable effort is made to reduce constraints to implementation. Also, the difference in Table 5-2 between potential benefit with unconstrained implementation of an action and potential benefit with constrained implementation is helpful in identifying where it might be worthwhile to expend effort to reduce constraints because the benefits would be great. This topic is discussed more fully in Chapter 7.

The threat index and scoring in Table 5-2 are for the estuary as a whole, instead of by reach, because in most cases the assessment information needed to do a reach-scale analysis currently is lacking. However, the severity of individual threats and limiting factors varies from reach to reach in the estuary, as do the potential benefits of the management actions. It is assumed that implementation of the management actions will involve dialogue and additional evaluation at the reach scale to aid in prioritizing actions and focusing them in the geographical areas where they would be most beneficial.

TABLE 5-2
Constraints to Implementation of Management Actions

Management Action CRE-1:

Protect intact riparian areas in the estuary and restore riparian areas that are degraded.

Primary threat this action would address		**Riparian Practices.** Riparian areas provide key ecological functions that affect water temperature, the availability of insects, and macrodetrital inputs to the ecosystem. Riparian areas in the lower Columbia River have been degraded by a number of factors, including shoreline modifications, diking and dike maintenance practices, and activities related to the disposal of dredged material.
Associated limiting factors		Water temperature, reduced macrodetrital inputs, and exotic plants.
Threat index[1]	10	This threat is a secondary contributor to two top-priority limiting factors (water temperature and reduced macrodetrital inputs) and a tertiary contributor to one additional limiting factor.
Potential benefits with unconstrained implementation of action [2]	4	Protecting intact riparian areas and restoring degraded riparian areas in priority reaches would provide significant benefits to salmonids by reducing water temperatures and increasing macrodetrital inputs to the system.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Levels of protection vary across the lower Columbia region. In some cases, riparian areas in cities and counties are protected through regulatory mechanisms such as growth management or shoreline rules. Regulatory tools such as buffer zones along streams can be effective but require broad public support over time. Restoration projects are expensive and can take decades to provide their full benefit to tributaries directly entering the estuary.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-2:

Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.

Primary threat this action would address		**Reservoir-related temperature changes.** Low-velocity flows and broad surface area exposure in reservoirs increase the temperature of flows in the estuary. Salmonids are cool-water fish that need stream temperatures of 20º C or lower for normal metabolism, growth, disease resistance, and timing of important life functions such as smoltification and adult migration. Salmonids in the estuary are experiencing water temperatures at the upper limit of their tolerance for longer periods and more frequently than they did historically.
Associated limiting factors		Water temperature.
Threat index[1]	10	This threat is a secondary contributor to a top-priority limiting factor.
Potential benefits with unconstrained implementation of action [2]	3	Given that at many times during the year water temperatures in the estuary are at or above the upper limits of salmonids' thermal tolerance, any lowering of water temperature could provide significant survival benefits. Water temperatures of below 20º C throughout the year would aid salmonids in carrying out essential physiological processes and life functions.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	5	Elevated temperatures that result from reservoir heating are difficult to reduce. Temperatures may be influenced by the volume and speed of flows through the hydrosystem and the source of those flows (some impoundments have cooler water than others do). International treaties, conflicting fish management objectives systemwide, the need for flood control, power management, and other factors constrain management of the hydrosystem to allow cooler flows to enter the estuary.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-3:

Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.

Primary threats this action would address		**Water withdrawal and impaired transport of coarse sediment.** Instream flows in the estuary are important for salmonids because they maintain habitat-forming processes and conditions in the estuary and plume. Transport of sand and gravel from upstream and estuary sources during high flows helps establish and maintain salmonid habitats, contributes to turbidity that shelters salmonids from predation, and influences food sources in the plume. Some instream flows have been established in Columbia River basin tributaries, but others are needed, especially with human population growth in the basin. This action focuses on water withdrawals in tributaries and the mainstem and other tributary flow issues, including tributary hydropower. It complements CRE-4, which focuses on mainstem hydrosystem flow-related issues, such as hydrosystem regulation, to establish incremental flow improvements in the estuary within the context of power generation and flood control.
Associated limiting factors		Flow-related estuary habitat changes, flow-related changes in access to off-channel habitat, flow-related plume changes, and reduced macrodetrital inputs.
Threat index[1]	12	This threat is a secondary contributor to four top-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	This action contributes incremental instream flow improvements that protect/enhance the flow regime in the estuary and plume and support associated habitat-forming processes.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings); stream-type salmonids in the plume.
Implementation constraints[3]	5	Implementation of this action would require the involvement of multiple stakeholders, including irrigation, commercial, industrial, hydrosystem, tribal, Federal, state, and local interests, plus significant public involvement. Establishing protected instream flows is challenging because of competing interests and often takes years.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-4:

Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.

Primary threats this action would address		**Flow regulation and impaired transport of coarse sediment.** The magnitude, frequency, and timing of flows are an important determinant of habitat opportunity for salmonids in the estuary. Salmonids have adapted to historical flows and depend on them to complete their life cycles. The transport of sand and gravel from upstream and estuary sources helps maintain salmonid habitats, contributes to turbidity that shelters salmonids from predation, and influences food sources in the plume. Spring freshets are important habitat-shaping events for the estuary and plume. Improved flow regimes would help ecological processes (and salmonids) by making nutrients and other food sources, such as insects, available in the food web.
Associated limiting factors		Flow-related estuary habitat changes, flow-related changes in access to off-channel habitat, flow-related plume changes, reduced macrodetrital inputs in the estuary, and sediment/nutrient-related estuary habitat changes.
Threat index[1]	15	This threat is a primary contributor to several top-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Return to a more natural flow regime would have significant ecosystem benefits and would affect all facets of salmonid life histories expressed in the estuary and plume. Adjustments to the timing, magnitude, and frequency of hydrosystem flows entering the estuary would be likely to have synergistic effects that would increase the benefit of many of the other actions.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies; stream-type juveniles rearing in the plume.
Implementation constraints[3]	5	Constraints on hydrosystem operations prevent the return to a natural flow regime in the estuary. Implementation of this action would be limited by international treaties, the need for flood control, fish management objectives systemwide, and power production. However, even slight modifications in the flow regime have the potential to provide significant ecosystem benefits.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-5:

Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.

Primary threat this action would address		**Entrapment of fine sediment in reservoirs.** Fine sediments originating from upstream sources are trapped in low-velocity impoundments in the Columbia River, and their movement into the estuary and plume has been reduced. This alters processes that form shallow-water habitats, affects food sources, and reduces turbidity that otherwise would shelter salmonids from predation.
Associated limiting factors		Flow-related plume changes and sediment/nutrient-related estuary habitat changes.
Threat index[1]	8	This threat is a secondary contributor to several high-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	Fine sediment transport processes are important determinants of estuary and plume habitats. Effective mitigation of this threat would reduce predation of salmonids in the main channel and plume and strengthen habitat-forming processes.
Affected salmonids		Ocean- and stream-type salmonids.
Implementation constraints[3]	5	There are no apparent technical solutions to this threat at this time. Mitigation is recommended, but research is needed to identify the magnitude of the threat and potential solutions or mitigation measures.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = significant potential for implementation.
5 = Current constraints to implementation are significant.

Management Action CRE-6:

Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.

Primary threat this action would address		**Impaired transport of coarse sediment.** The transport of sand and gravel from upstream and estuary sources is a primary force that influences the creation, maintenance, and distribution of salmonid habitats in the estuary. While there are many potential beneficial uses of dredged materials—including enhanced nourishment of the littoral cell, land creation, property stabilization, and out-of-stream uses—there is also an important ecological need to retain coarse sediments in the estuary for habitat creation and maintenance.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes and flow-related plume changes.
Threat index[1]	12	Although impaired transport of coarse sediment is a primary contributor to a top-priority limiting factor (flow-related plume changes), this management action is likely to have its greatest effect in addressing sediment/nutrient-related estuary habitat changes, a high-priority limiting factor; thus it has a threat index of 12.
Potential benefits with unconstrained implementation of action [2]	2	The beneficial use of sand resulting from dredge activities could play an important role in restoring habitat capacity and habitat opportunity in the estuary and plume. The beneficial use of dredged materials to provide sand nourishment could reduce the effects of ship wake stranding, improve habitat for *Americorphium* (a food source for salmonids), and be beneficial in the development of intertidal swamps and marshes and other salmonid habitat features. Sand entering the littoral cell could also have important ecological benefits.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings). This particularly applies to ocean-type juveniles because of their significant use of shallow-water habitats and the nearshore environment.
Implementation constraints[3]	3	Beneficial uses of dredged materials, such as through littoral cell sand nourishment and direct beach nourishment, are currently receiving significant attention, The most obvious constraint to implementation is identifying funding sources to pay for activities beyond the minimum required by law.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-7:

Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

Primary threat this action would address		**Dredging**. Annual dredge operations maintain a navigational channel that concentrates flows, alters tidal influences, reduces circulation patterns around the estuary, and releases toxic contaminants from substrates. Dredging activities can result in deposited contaminants being disturbed and redistributed throughout the estuary. Dredging activities also result in the entrainment of juvenile salmonids and benthic organisms through the physical removal of sand via pipeline or clamshell dredging. Ship ballast intake may also result in the entrainment of juveniles as ships take on ballast water when exiting port facilities.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes, native birds, and sediment/nutrient-related plume changes.
Threat index[1]	8	As it relates to this action, dredging is a secondary contributor to a high-priority limiting factor (sediment/nutrient-related estuary habitat changes) and thus has a threat index of 8.
Potential benefits with unconstrained implementation of action [2]	2	Continued dredge operations represent a physical change to the Columbia River estuary. However, reducing or mitigating the effects of dredging would improve habitat-forming processes that would benefit salmonids. Reduction of entrainment through new technologies or management practices for both dredging and ship ballast intake would reduce mortality of juveniles.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	2	Dredging activities have been occurring since the 1870s to provide sufficient draft for ships entering the Columbia River and will continue into the foreseeable future. Ongoing maintenance is needed to keep the channel to specifications for ships, and additional dredging will be conducted in the estuary as part of the channel deepening process. Maintaining the navigation channel requires dredging and disposal of large volumes of material (4 to 5 million cubic yards) each year. Changing dredging equipment, ballast water intake screens, and practices to reduce entrainment and habitat effects would be expensive.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.

1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.

1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-8:

Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.

Primary threat this action would address		**Pilings and pile dike structures**. Extensive use of pilings and pile dikes has altered sediment accretion and erosion processes and reduced flow circulation through shallow-water habitats in the estuary. Pile structures also have created favorable conditions for predators of salmonids and can reduce physical access to low-velocity juvenile salmonid habitats. In some cases, treated pilings may release toxic contaminants, including PAHs, and it can be beneficial to remove these structures. In other cases, pile structures may protect riparian areas from erosion and wave energy, collect large wood to form complex habitat, and stimulate sediment accretion in the creation of habitat. In these cases, maintenance or modification of existing structures may be beneficial.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes, sediment/nutrient-related plume changes, exotic fish, native birds, and bioaccumulation toxicity.
Threat index[1]	12	This threat is a primary contributor to a high-priority limiting factor (altered predator/prey relationships), a secondary contributor to a high-priority limiting factor (sediment/nutrient-related estuary habitat changes) and two low-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	4	Removing many instream structures would improve circulation in shallow-water habitats and eliminate some salmonid predator habitats.
Affected salmonids		Ocean-type salmonids; stream-type salmonids (yearlings) leaving the heavier flows to forage in shallow waters downstream of pilings and pile dikes; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings);
Implementation constraints[3]	2	Only some of the thousands of pilings, pile dikes, and similar structures in the Columbia River estuary are necessary to maintain the shipping channel, protect property, or serve their intended economic use. Removal of superfluous structures generally is restricted only by cost and would be unlikely to affect property rights or the shipping industry. In cases where pile dikes that do aide in navigation are removed, constraints to implementation would include the cost for additional dredging to maintain the channel.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-9:

Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.

Primary threat this action would address		**Dikes and filling.** High-quality off-channel habitat provides crucial feeding, rearing, and refuge opportunities for juvenile salmonids and supplies macrodetrital inputs to the estuarine food web. Reduced floodplain inundation has limited juvenile salmonids' access to historical wetland and swamp habitat, much of which has been converted to other land uses. Protecting remaining intact and accessible off-channel habitats and restoring accessible but degraded off-channel areas are critical to maintaining key habitats and food sources for juvenile salmonids.
Associated limiting factors		Reduced macrodetrital inputs, sediment/nutrient-related estuary habitat changes, bankfull elevation changes, sediment/nutrient-related plume changes, and exotic plants.
Threat index[1]	15	This threat is a primary contributor to both top-priority and high-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Protecting high-quality off-channel areas would help maintain important wetland habitats and supply macrodetrital inputs to the food web and insect food sources for juvenile salmonids—a main component of their diet. Restoring or enhancing accessible but degraded off-channel areas in the estuary represents a largely untapped strategy that could provide similar benefits. Benefits from this strategy likely would be realized more quickly than from the passive restoration associated with CRE-10.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Regulatory programs often do not effectively protect floodplains from conversion to other uses. The acquisition of land for habitat protection remains controversial in the estuary. Rural county governments see land disappearing off tax rolls and also listen to citizen disapproval of public ownership of land. Land acquisition is expensive and depends on the willingness of landowners to sell. Restoring accessible off-channel habitat also depends on willing landowners .The fact that many habitats already have been converted to other land uses limits opportunities to protect high-quality off-channel habitat.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-10:

Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.

Primary threat this action would address		**Dikes and filling.** Many juvenile salmonids rely on off-channel habitats for feeding and refuge opportunities. Historically, insects and macrodetritus from these habitats were important inputs to the estuarine food web. Dikes, levees, tide gates, and filling have limited the amount and accessibility of key off-channel habitats by reducing floodplain inundation and allowing conversion of land to agricultural, residential, and industrial uses. This action would allow juvenile salmonids access to habitats and food sources that currently are unavailable to them and support improved habitat conditions over time.
Associated limiting factors		Reduced macrodetrital inputs, sediment/nutrient-related estuary habitat changes, bankfull elevation changes, sediment/nutrient-related plume changes, and exotic plants.
Threat index[1]	15	This threat is a primary contributor to both top-priority and high-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Establishing or improving access to off-channel areas via dike breaching and similar activities would reclaim habitat that is important to salmonids. Over time, improved hydrology would support reestablishment of wetland vegetation and salmonid food sources in off-channel areas, through passive restoration. In most cases, project benefits would accrue over relatively long periods of time.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Opportunities to establish or improve access to off-channel habitats are limited because many such habitats already have been filled with dredged materials. Breaching, lowering, or relocating dikes and levees or removing tide gates often requires the cooperation of multiple landowners and may fundamentally alter land uses. The associated habitat restoration is expensive.
Potential benefits with constrained implementation of action	4	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-11:

Reduce the square footage of over-water structures in the estuary.

Primary threat this action would address		**Over-water structures.** Over-water structures may provide habitats for predators and affect instream and shoreline plant communities. However, the total surface area of over-water structures in the estuary has not been quantified and the structures' case-by-case functions have not been analyzed.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes and exotic fish.
Threat index[1]	4	This threat is a tertiary contributor to a high-priority limiting factor (habitat changes) and a secondary contributor to one of the lowest priority limiting factors (exotic fish).
Potential benefits with unconstrained implementation of action [2]	3	Given the uncertainty about how much of a threat over-water structures actually pose to salmonids, the potential improvement in survival must be considered low pending additional research and analysis.
Affected salmonids		Ocean-type salmonids (because of their preference for the shallow-water habitats where most structures are located); stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	It is assumed that some over-water structures are more important than others and that removing superfluous or less useful structures would not have deleterious effects on adjacent land uses. Removal of over-water structures that are in currently use would likely require compensation. In some cases, structures such as log rafts could be relocated.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-12:

Reduce the effects of vessel wake stranding in the estuary.

Primary threat this action would address		**Ship wakes.** Wakes from deep-draft vessels traveling through the estuary wash subyearling salmonids onto shore, leaving them stranded. Factors that affect stranding include beach slope and time of day as well as vessel draft, speed, and hull design.
Associated limiting factors		Stranding.
Threat index[1]	6	This threat is a primary contributor to a low-priority limiting factor.
Potential benefits with unconstrained implementation of action [2]	2	The extent of mortality caused by ship wake stranding is unknown. Studies in 1977 and 1994 (Bauersfeld 1977, Hinton and Emmett 1994) reached different conclusions, using different approaches. A soon-to-be-released study by the University of Washington and U.S. Army Corps of Engineers may provide further clarification of the issue.
Affected salmonids		Ocean-type salmonids (because of their longer estuarine residency times, their relatively small size, and the habitats they prefer); stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Options for reducing the effects of vessel wake stranding are limited, primarily because of the lost revenues that would result from slower ship travel. Ship traffic through the estuary will continue, ship hull design is unlikely to change, and the speed of ships traveling the estuary may be difficult to alter. Modification of some habitats may be necessary to reduce this threat and would likely be expensive.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-13:

Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.

Primary threat this action would address		**Altered predator/prey relationships.** Pikeminnows have always been a significant source of mortality for juvenile salmonids in the Columbia River, but changes in physical habitat, such as the addition of in-water structures, have created more favorable conditions for predation by pikeminnow. Introduced species such as smallmouth bass, walleye, and channel catfish also prey on juvenile salmonids, primarily in the freshwater reaches.
Associated limiting factors		Native fish and exotic fish.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action addresses only the native and exotic fish limiting factors, which have threat indexes of 12 and 3, respectively.
Potential benefits with unconstrained implementation of action [2]	4	Ecosystem alterations in the estuary as a result of pikeminnow, smallmouth bass, walleye, and channel catfish are uncertain. Scientists speculate that pikeminnow may be preying on both ocean- and stream-type juveniles. Stream-type juveniles may be affected significantly more than previously thought because evidence suggests that they forage in shallow areas downstream of piling structures.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	2	Because of their abundance, pikeminnow appear to be a far greater threat to juvenile salmonids than bass, walleye, and channel catfish, at least at this time. Implementation activities to reduce pikeminnow predation are constrained by the challenge of reducing their preferred slack-water habitats. Bounty programs can be effective at removing older pikeminnow, which represent the largest threat to salmonids. Although the introduction of exotic fish to the estuary may be irreversible, there are viable tools for managing smallmouth bass, walleye, and channel catfish; these include habitat management and less restricted harvest management. It is likely that warm-water fishers would actively support maintaining the abundance of these species at current—rather than reduced—levels.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-14:

Identify and implement actions to reduce salmonid predation by pinnipeds.

Primary threat this action would address		**Altered predator/prey relationships.** Pinniped predation on adult salmonids at Bonneville Dam has been estimated at between 0.4 percent (2002) and 4.2 percent (2007) of the spring Chinook and winter steelhead runs, or possibly as high as 8.5 percent and 20 percent, respectively (based on radio-telemetry studies). The extent of predation needs further study and documentation.
Associated limiting factors		Native pinnipeds.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action relates only to native pinnipeds.
Potential benefits with unconstrained implementation of action [2]	3	Actions to reduce predation by pinnipeds would have moderate impacts on salmonid survival, depending on how many adults are actually being consumed by pinnipeds—a question that remains uncertain.
Affected salmonids		Ocean- and stream-type salmonids.
Implementation constraints[3]	4	Methods for reducing salmonid predation by pinnipeds are limited because pinnipeds are protected under the Marine Mammal Protection Act (MMPA). It could take years to amend the act to allow additional pinniped management tools. Non-lethal methods have been only minimally successful, although it is possible that additional testing would identify effective non-lethal methods. In 2008, NMFS granted Washington, Oregon, and Idaho authority to use and evaluate lethal methods of control under Section 120 of the MMPA.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-15:

Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.

Primary threat this action would address		**Altered predator/prey relationships.** Exotic plants in the estuary often out-compete native plants and change the structure of plant communities. The resulting habitat frequently does not provide the same food or shelter that other species, including salmonids, have adapted to over time.
Associated limiting factors		Exotic plants.
Threat index[1]	3	This threat contributes to many limiting factors, although the management action relates only to exotic plants, one of the lowest priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	Preventing and controlling invasive plants would help maintain the estuarine food web and habitats that juvenile salmonids rely on.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	4	Controlling existing infestations of certain species is functionally impossible once the species are established. Although landowners are the most important agents in preventing and controlling exotic plant infestations, landowner education is a significant task that requires a large effort.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-16:

Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.

Primary threat this action would address		**Altered predator/prey relationships.** Caspian tern predation represents a significant source of mortality for stream-type juveniles migrating to saltwater. Stream-type salmonids are particularly vulnerable because of the timing of their out-migration (during tern nesting season) and their preference for deep-channel habitats near tern nesting sites.
Associated limiting factors		Native birds.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action relates only to Caspian terns.
Potential benefits with unconstrained implementation of action [2]	5	Reducing tern predation could have significant effects on the survival of stream-type salmonids, as terns have been documented to consume as much as 3 percent of stream-type juveniles migrating through the estuary.
Affected salmonids		Stream-type salmonids; ocean-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	2	Management efforts have helped reduce mortality by relocating terns to nearby habitats. Long-term solutions will require habitat improvements elsewhere for Caspian terns.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-17:

Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.

Primary threat this action would address		**Altered predator/prey relationships.** Predation by double-crested cormorants represents a significant source of mortality for stream-type juveniles migrating to saltwater.
Associated limiting factors		Native birds.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action relates only to double-crested cormorants.
Potential benefits with unconstrained implementation of action [2]	4	Studies indicate that double-crested cormorants prey on salmonid juveniles in the estuary at a rate equal to or greater than the rate by Caspian terns. Cormorants are estimated to have consumed an average of 7 million juvenile salmonids annually over the years 2001 to 2009.
Affected salmonids		Ocean- and stream-type juvenile salmonids are preyed upon by double-crested cormorants with some fluctuation from year to year. In 2009 double-crested cormorants consumed approximately 11 million juvenile salmonids.
Implementation constraints[3]	4	Double-crested cormorants are more difficult to relocate than Caspian terns. Techniques such as the use of decoys and audio playback have not been as effective compared to terns. Perch habitats are plentiful enough in the estuary that removal of pile dikes and other structures may not be an effective tool.
Potential benefits with constrained implementation of action	2	

[1] *From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.*

[2] *Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.*
1 = very low benefits.
5 = very high benefits.

[3] *Indicates the feasibility of implementing the action.*
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-18:

Reduce the abundance of shad in the estuary.

Primary threat this action would address		**Altered predator/prey relationships.** Shad returns to the Columbia River number approximately 4 million annually. Shad's effects on the estuary ecosystem and salmonids are poorly understood. However, shad are an introduced species and their biomass alone represents a threat to trophic relationships in the Columbia River.
Associated limiting factors		Exotic fish.
Threat index[1]	3	This threat contributes to many limiting factors, although the management action relates only to shad.
Potential benefits with unconstrained implementation of action [2]	2	The impacts of shad in the estuary are unclear. However, it is likely that reducing shad numbers would have some benefits for salmonids.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	5	Shad are thought to have permanently altered the estuary ecosystem, and their complete removal from the estuary is neither practical nor feasible. Effective management tools to limit shad productivity in the Columbia River basin currently are not available. Research is needed in the near term to determine the significance of this threat and identify potential management actions to manage the abundance of shad.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-19:

Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.

Primary threat this action would address		**Ship ballast practices.** Ship ballast water is responsible for the introduction of non-native aquatic invertebrates in the estuary. The effects of these introductions are poorly understood, but it is likely that exotic invertebrates disrupt food webs and out-compete juvenile salmonids' native food sources.
Associated limiting factors		Introduced invertebrates.
Threat index[1]	3	This threat is a primary contributor to one of the lowest priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	Reducing the impacts of non-native aquatic invertebrates would help maintain traditional salmonid food sources and the trophic relationships that salmon have adapted to.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	4	Improvements in ship ballast practices have already been implemented by the industry as a result of new regulations, and stricter regulations are currently being debated at the Federal level. However, there are inherent challenges in managing ballast water that contains organisms from other ecosystems. Also, once non-native aquatic invertebrates have been introduced, they represent a permanent alteration of the ecosystem and opportunities to reduce their effects may be few. Current understanding of how the estuary ecosystem is affected by introductions of exotic invertebrates is very limited.
Potential benefits with constrained implementation of action	1	

[1] *From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.*

[2] *Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.*
1 = very low benefits.
5 = very high benefits.

[3] *Indicates the feasibility of implementing the action.*
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-20:

Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.[1]

Primary threat this action would address		**Agricultural practices.** Fertilizers include different forms of nutrients that are important for plant growth. When fertilizers make their way to the estuary through overland runoff, they contribute nutrients to the estuary that increase phytoplankton production, alter the food web, and in some instances depress dissolved oxygen levels. Water-soluble contaminants such as simazine, atrazine, chlorpyrifos, metolachlor, diazinon, and carbaryl enter the estuary as a result of tributary and upstream agricultural practices. DDT and PCBs have been detected at elevated levels in the estuary. These and other agricultural contaminants can cause salmonid mortality through bioaccumulation or non-bioaccumulative toxicity.
Associated limiting factors		Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.
Threat index [2]	12	This threat is a primary contributor to a high-priority limiting factor (non-bioaccumulative toxicity) and a medium-priority limiting factor.
Potential benefits with unconstrained implementation of action [3]	3	Reducing the level of pesticides and herbicides in the estuary would improve survival by reducing ocean-type salmonids' acute and chronic exposure to toxic contaminants and stream-type salmonids' acute exposure.
Affected salmonids		Ocean- and stream-type salmonids.
Implementation constraints[4]	4	Impacts from pesticides and fertilizers have lessened dramatically since the 1950s as a result of new application technologies, new products, and better understanding and regulation of these toxins. More extensive compliance with existing regulations and usage guidelines, along with development of additional best management practices, could further reduce the impacts of pesticides and fertilizers. The integration of new practices can be expensive and time-consuming.
Potential benefits with constrained implementation of action	1	

[1] The term best management practices is used here to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

[2] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[3] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[4] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-21:

Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.

Primary threat this action would address		**Urban and industrial practices.** The estuary has been affected by historical and current releases of toxic contaminants, including industrial and commercial pollutants such as PCBs and PAHs. These substances have been found near Portland, Vancouver, Longview, and Astoria. Studies have demonstrated significant juvenile mortality in the estuary as a result of toxic contaminants. In addition, urban and industrial effluent and stormwater runoff are principal sources of nutrients that can support increased phytoplankton levels.
Associated limiting factors		Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.
Threat index[1]	12	This threat is a primary contributor to high- and medium-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	4	Reducing sources of pollutants would lower water temperature, nutrient loading, and the amount of toxic contaminants in the estuary. This would improve both habitat capacity in the estuary and the fitness level of salmonids.
Affected salmonids		Ocean- and stream-type salmonids (particularly ocean types because of their longer residency in the estuary).
Implementation constraints[3]	4	While some discharges of industrial and commercial pollutants are permitted, others are not. Efforts to reduce industrial and commercial pollutants are already under way, and there is potential to reduce point-source emissions. Efforts to reduce sources of pollutants are expensive and time-consuming and often have a negative economic effect on operations.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-22:

Restore or mitigate contaminated sites.

Primary threat this action would address		**Urban and industrial practices.** The estuary has been affected by historical and current releases of toxic contaminants, including industrial and commercial pollutants such as PCBs and PAHs. These substances have been found near Portland, Vancouver, Longview, and Astoria. Studies have demonstrated significant juvenile mortality in the estuary as a result of toxic contaminants. The action is intended to address the need to monitor the entire estuary for contaminants; however, actual restoration activities are feasible only in specific reaches.
Associated limiting factors		Non-bioaccumulative toxicity and bioaccumulation toxicity.
Threat index[1]	12	This threat is a primary contributor to high- and medium-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Reducing toxic contaminants in the estuary would improve both habitat capacity and the fitness level of salmonids.
Affected salmonids		Ocean- and stream-type salmonids (particularly ocean types because of their longer residency in the estuary).
Implementation constraints[3]	3	Monitoring activities are already occurring; however, actual restoration of contaminated sites is expensive and technically challenging in many cases. In cases where restoration is not feasible, the effects of contaminated sites should be mitigated.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-23:

Implement stormwater best management practices in cities and towns.[1]

Primary threat this action would address		**Urban and industrial practices.** Municipal stormwater runoff can convey nutrients and toxic contaminants to the estuary, reduce groundwater recharge, and increase the "flashiness" of stream flows. Although cities and towns in the Columbia River basin generally have programs to reduce the impacts of stormwater runoff, stormwater best management practices have not been universally accepted or implemented throughout the basin.
Associated limiting factors		Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.
Threat index[2]	9	This threat is a secondary contributor to a medium-priority limiting factor as it relates to this management action.
Potential benefits with unconstrained implementation of action [3]	2	Identifying and implementing stormwater best management practices throughout the Columbia River basin would improve conditions and provide a net benefit to salmonids in the estuary through a more normal flow regime, reduced exposure to contaminants, and lower water temperatures.
Affected salmonids		Ocean- and stream-type salmonids (particularly ocean types because of their longer residency in the estuary).
Implementation constraints[4]	2	Some cities lack the resources or will to implement or enforce stormwater best management practices. The benefits of improved stormwater practices generally are associated only with new development and do not offset the full impact of the impervious surfaces in those developments, or the existing impervious surfaces in areas that have already been developed.
Potential benefits with constrained implementation of action	1	

[1] The term best management practices is used here to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

[2] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[3] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[4] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Table 5-2 estimates the potential of each management action to benefit salmonids under two different implementation scenarios. Assuming that implementation of most actions is significantly constrained, which management actions would be likely to result in the greatest survival improvements?

In partial answer to this question, Table 5-3 summarizes the potential benefits of each action under both unconstrained and constrained implementation scenarios. It is tempting to sort the actions in Table 5-3 by potential benefit with constrained implementation and view the sorted list as a prioritized list of management actions, with the actions at the top being those predicted to have the greatest benefits. Although Table 5-3 does provide insight into the relative benefits of the various management actions, it is perhaps most useful as a means of contrasting the benefits that might be achieved with unconstrained implementation of an action with the benefits that might be achieved under a more likely scenario of constrained implementation.

To provide greater insight into the relative benefits of each management action, PC Trask & Associates, Inc., developed a second analysis based on survival improvement targets. This analysis, which is presented in the next section of the document, is more refined and specific than the analysis in Table 5-3. For instance, it focuses more on how the potential benefits of the 23 management actions would compare to each other and on the survival benefits that might be gained from each action. It also evaluates the benefits of each action to both ocean- and stream-type salmonids.

TABLE 5-3
Summary of Constraints to Implementation of Management Actions

Number	Action Description	Benefit with Unconstrained Implementation of Action[1]	Benefit with Constrained Implementation of Action[2]
CRE-01	Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	4	2
CRE-02	Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	3	2
CRE-03	Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	2	1
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	5	3
CRE-05	Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	2	1
CRE-06	Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	2	1

Number	Action Description	Benefit with Unconstrained Implementation of Action[1]	Benefit with Constrained Implementation of Action[2]
CRE-07	Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	2	1
CRE-08	Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	4	2
CRE-09	Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	5	3
CRE-10	Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	5	4
CRE-11	Reduce the square footage of over-water structures in the estuary.	3	1
CRE-12	Reduce the effects of vessel wake stranding in the estuary.	2	1
CRE-13	Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	4	2
CRE-14	Identify and implement actions to reduce salmonid predation by pinnipeds.	3	2
CRE-15	Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	2	1
CRE-16	Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	5	3
CRE-17	Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	4	2
CRE-18	Reduce the abundance of shad in the estuary.	2	1
CRE-19	Prevent new introductions of invertebrates and reduce the effects of existing infestations.	2	1
CRE-20	Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	3	1
CRE-21	Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	4	3
CRE-22	Restore or mitigate contaminated sites.	5	3
CRE-23	Implement stormwater best management practices in cities and towns.	2	1

[1]Estimate of potential benefit if action is fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[2]Estimate of potential benefit assuming that implementation is constrained.
1 = very low benefits.
5 = very high benefits.

Evaluation of Management Actions: Survival Improvement Targets

The Columbia River estuary and plume are only two of many ecosystems that salmonids travel in their complex and lengthy journey from headwaters to ocean and back again. Mortality occurs at every stage of this journey. Each year, scientists from the NMFS Northwest Fisheries Science Center estimate the number of juvenile salmonids that enter the estuary from upstream of Bonneville Dam and from estuary tributaries. For 2006, scientists from NMFS estimated that about 168 million juvenile salmonids (both wild and hatchery) would enter the estuary (Ferguson 2006b). Some years later, the surviving fish return to the estuary in varying numbers, with the average return in the last 10 years being approximately 1.7 million fish; roughly 65 to 75 percent of those fish are of hatchery origin.[1] This means that less than 1 percent of the juveniles that enter the estuary are returning as adults.

Estimating Juvenile Mortality in the Estuary and Plume

How much juvenile mortality is occurring in the estuary and plume? The answer to this question is fundamental to developing an understanding of the role the estuary will play in the recovery of salmonid populations basinwide. The answer also is critical in evaluating the benefits and costs of potential management actions because it helps establish the level of effort needed to offset threats to salmonids in the estuary. Unfortunately, determining how much juvenile mortality is occurring in the estuary and plume is challenging for scientists. Counting juveniles in the Columbia River estuary and plume is problematic because available tracking technologies are limited, and it is difficult to monitor juveniles—which tend to move in and out of saltwater—in large, high-energy sites such as the mouth of the Columbia River.

However, some efforts have been made to separate mortality that occurs in the estuary and plume from mortality that occurs in the ocean. One such effort has been the underlying assumptions in the Ecosystem Diagnosis and Treatment (EDT) model, which is used extensively throughout the Columbia River basin. For juveniles entering the estuary from tributaries to the lower Columbia River, EDT assumes mortality rates in the estuary and plume of between 18 and 58 percent, depending on the salmonid species and the amount of time juveniles spend in the estuary (Lower Columbia Fish Recovery Board 2004). In a study of juvenile mortality in the estuary, Schreck et al. (2006) estimated spring/summer Chinook mortality at between 11 and 17 percent, largely from avian predation.

In addition, research is under way by NMFS, the U.S. Army Corps of Engineers, and Battelle Laboratories to estimate the survival rate of juvenile salmonids in the lower Columbia River. This research involves new technologies for miniaturizing acoustic tags to a size capable of tracking yearling and subyearling juveniles. Current technology developed for the project allows for the tracking of subyearlings of sizes down to approximately 90 mm. Results for the first year (2005) indicated an approximate range of survival of 65 to 75 percent for subyearlings and yearlings during their residency in the estuary (Ferguson 2006a). It is probable that actual survival rates are lower than these preliminary estimates suggest

[1] This is an informal estimate; determining the ratio of hatchery-origin fish with more certainty would require stock-by-stock run calculations averaged over many years.

because the research did not address mortality among juveniles smaller than 90 mm or mortality occurring in the plume and nearshore. The studies above have not been conclusive, and separating estuarine and ocean mortality for juvenile salmonids in the Columbia River remains significant challenge.

Some specific estimates of salmonid mortality are known in the estuary; they include estimates for double-crested cormorants and Caspian terns. For other threats to salmonids, such as toxic contamination, ship wake stranding, and pinniped predation, information on mortality in the estuary is incomplete or relatively new in the literature. Still other threats, especially those related to the food web, are poorly understood and have no mortality estimates associated with them, although in some cases the change in conditions from the historical template to the present has been well documented.

Establishing Survival Improvement Targets

An important goal of this estuary recovery plan module is to estimate the potential benefits—in terms of increased survival of salmonids in the estuary—that could result from the implementation of different management actions. To accomplish this goal, PC Trask & Associates, Inc., used available information about limiting factors, threats, and constraints to the implementation of management actions to assign benefits that could possibly result from different actions.

If scientific understanding of the relationships between ecological conditions and biological responses in estuarine systems were robust, it would be attractive to assign specific mortality rates to each of the factors limiting salmonids' biological performance in the Columbia River estuary. Then one could follow a deterministic logic path that associates mortality rates with specific threats, relates the mortality rates to management actions, and ultimately arrives at an estimate of the survival improvement that would be likely to result from each action. This is not possible at this time, and it will likely not be possible until there have been significant advances in scientific understanding of the complex estuarine environment.

To compensate for the lack of detailed information on mortality in the estuary, PC Trask & Associates, Inc., established targets for improved survival of wild ESA-listed salmonids rearing and migrating in the estuary and plume, assuming that the implementation of management actions is constrained to the degree indicated in Table 5-2. PC Trask & Associates, Inc., then allocated these survival targets to individual management actions. These targets are intended to serve as a planning tool useful in characterizing the potential results of actions and describing the level of effort needed to recover salmonids.

The primary purpose of the survival improvement targets is to help compare the potential benefits of different management actions, particularly actions that partially address major limiting factors versus actions that fully address minor limiting factors. In addition, the survival improvement targets provide insight into the specific survival benefits of each action and the differential benefits of each action to stream- and ocean-type salmonids. Numerically, the survival improvement targets in this chapter were based on an estimate of the number of naturally produced ESA-listed ocean- and stream-type juvenile salmonids entering the estuary. The total number of naturally produced ESA-listed juvenile salmonids

estimated to enter the estuary in 2006 was approximately 39 million (Ferguson 2006b).[2] Of these, approximately 25 million were estimated to be ocean type and 14 million were estimated to be stream type.

To establish survival improvement targets, PC Trask & Associates, Inc., developed some assumptions about the overall mortality of juvenile salmonids during estuary and plume residency. Ocean-type juveniles were assumed to have an overall mortality rate of 50 percent during their estuary residency; this includes the 35 percent mortality suggested by the unpublished micro-acoustic tagging research (Ferguson 2006a) plus an additional 15 percent to account for juveniles too small to be tracked. Stream-type juveniles were assumed to have an overall mortality rate of 40 percent during estuary and plume residency. This rate was based on the 25 percent mortality found in the micro-acoustic tagging research (Ferguson 2006a) plus an additional 15 percent to account for mortality occurring in the plume, which was not part of study. These assumptions about estuary mortality are based on best professional judgment by PC Trask & Associates, Inc., after a review of pertinent literature and discussions with subject matter experts, including scientists at the NMFS Northwest Fisheries Science Center.

Table 5-4 shows the number of wild, ESA-listed ocean- and stream-type juveniles thought to be entering the lower Columbia estuary and plume, their estimated mortality and survival rates based on the assumptions above, and the number of juveniles estimated to survive their journey through the estuary and plume—again, based on the assumptions above.

TABLE 5-4
Estimated Mortality Rates, Survival Rates, and Survival Improvement Targets for Wild, ESA-Listed Juveniles

Type	Juveniles Entering Estuary*	Assumed Mortality Rate	Assumed Survival Rate	Estimated Number of Juveniles Exiting Estuary and Plume*	Survival Improvement Target (20 percent)**
Ocean Type	25 million	50%	50%	12.5 million	2.5 million***
Stream Type	14 million	40%	60%	8.4 million	1.68 million***

* = Wild, ESA-listed juveniles.

** = Twenty percent of the estimated number of juveniles exiting the estuary and plume; this target represents additional fish surviving their estuary and plume residency.

*** These numbers are used to characterize the potential, relative benefits of implementing various management actions and do not represent actual numbers of additional fish expected to survive.

Table 5-4 also presents survival improvement targets for ocean- and stream-type salmonids in the estuary and plume. For planning purposes only, this estuary recovery plan module selects 20 percent as a target for improvement in the survival rate of wild, ESA-listed ocean- and stream-type juveniles in the estuary and plume. Twenty percent represents a hypothetical level of improvement that might be realized through the implementation of the management actions, assuming that considerable effort is expended to help offset constraints to implementation, such that threats and limiting factors are reduced. For ocean types, increasing survival by 20 percent would result in a total of 15 million juveniles exiting

[2] Current scientific information on the effects of limiting factors and actions does not differentiate between hatchery- and natural-origin salmon and steelhead, or between salmon and steelhead that are listed under the ESA and those that are not. Because ESA recovery is determined by the status of natural-origin fish, the intent of the module is to improve the estuarine survival of naturally produced, ESA-listed salmon and steelhead. Naturally produced fish are the focus of the analysis of survival improvement targets because they are the focus of the module.

the estuary and plume—2.5 million more juveniles than the current estimate of 12.5 million. For stream types, a 20 percent improvement would equal 10.08 million—1.68 million additional juveniles beyond the current 8.4 million that are estimated to exit the estuary and plume. Thus the survival improvement targets for ocean- and stream-type salmonids are 2.5 million and 1.68 million, respectively, as shown in Table 5-4. Targets for both types were set at 20 percent to avoid the appearance of a false level of precision in establishing them. Ocean-type juveniles were assumed to incur more mortality in the estuary and nearshore compared to stream types. Stream types were assumed to incur less mortality in the estuary than ocean types but significantly more mortality in the plume.

PC Trask & Associates, Inc., selected the 20 percent survival improvement number for ocean- and stream-type juvenile salmonids based on a qualitative analysis of the level of improvement that reasonably and plausibly might be expected if the 23 management actions were implemented. In establishing the 20 percent target, PC Trask & Associates, Inc., reviewed existing management plans, other literature sources, and the constraints analysis in Table 5-2. However, setting 20 percent as the target for improvement, rather than 15 or 30 percent, is inherently subjective and relies in part on the following assumptions:

- That estuary mortality for juveniles (currently between 40 and 50 percent, depending on population) can be reduced by initiating restoration projects and reducing uncertainties through research and monitoring
- That mortality rates associated with certain threats, such as Caspian terns and cormorants, are well understood and will be lessened through actions specified in management plans that are reasonably likely to be implemented
- That all of the actions identified in this chapter are implemented to a reasonable degree and historical and current constraints to action implementation are thoroughly challenged

Actual improvements in survival will depend on which management actions are implemented, how fully they are implemented, and their efficacy—factors that at this point are open to interpretation and can be qualitatively estimated only. Although the 20 percent targets for ocean- and stream-type salmonids are intended to be reasonable and plausible given the information available to date, open technical, political, and social discussion could refine the targets until science can substantiate them.

The survival improvement targets in Table 5-4 were developed using ocean- and stream-type life history strategies to characterize the 13 ESUs in the Columbia River basin. As a result, the survival improvement targets do not account for important variations found at the ESU, population, and subpopulation scales. For example, not all ocean-type ESUs in the Columbia River basin exhibit the same run timing, size at estuary entry, or use of particular habitats (Fresh et. al 2005). In fact, this variability in estuarine use by the ESUs is fundamental to the member/vagrant theory proposed by the NMFS Northwest Fisheries Science Center and a central premise of the estuary recovery plan module (see Chapter 2 for more information on the member/vagrant theory). Although genetic and spatial diversity are not explicitly accounted for in survival improvement targets, the suite of management actions identified in the estuary recovery plan module is intended to collectively address all life history strategies historically expressed in the estuary and plume. This further

emphasizes that the survival improvement targets are best viewed as a planning tool only. In reality, there will be significant variability among ESUs, populations, and subpopulations in how much additional survival might result from improvements in estuary and plume habitat.

Assigning Survival Improvement Targets to Recovery Actions

The usefulness of the 20 percent target lies not in the 20 percent number itself, but in the distribution of the targets (2.5 million ocean-type juveniles and 1.68 million stream-type juveniles) across the various management actions, as a way of characterizing the relative benefits of the various management actions.[3] Table 5-5 shows this allocation of survival improvement targets to the 22 management actions for juvenile salmonids.[4] In cases where there is good scientific literature that supports the allocation of survival targets, as with terns and cormorants, PC Trask & Associates, Inc., used that information as a basis for the analysis in Table 5-5. In other cases, such as reservoir-related temperature changes, PC Trask & Associates, Inc., estimated survival improvements based on literature discussion of related limiting factors and threats. The reader should view the resulting survival improvement targets as the product of a planning exercise, not a representation of deterministically based estimates. (Appendix B presents more information on how PC Trask & Associates, Inc., allocated survival improvement targets to the different actions.)

Although the survival improvement targets in Table 5-5 are estimates only, they complement the analysis summarized in Table 5-3.[5] In addition, they provide a useful way to show the potential magnitude of juvenile survival at the action scale relative to other actions. The survival improvement targets illustrate how a small increment of implementation of a far-reaching action could offer significantly more potential for recovery than full implementation of an action that is more limited in scope. Comparison of Tables 5-3 and 5-5 and the cost estimates that are developed in the next section form the basis for prioritization of actions in Chapter 7, "Perspectives on Implementation."

A special case in assigning survival improvement targets to actions are those actions (CRE–01 and CRE–09) that use land protection as a means of achieving the target. In theory, protection projects contribute only to maintenance of baseline conditions and not to recovery. However, the estuary recovery plan module does assign a portion of the survival improvement targets to protection projects. The reasoning here is that without protection of baseline environmental conditions, significantly more effort would be required in restoration projects to offset the continued loss of functioning habitat that would result from increases in the human population and corresponding conversion of habitats to economically beneficial land uses. Thus, assigning survival improvement targets to

[3] Although for the purposes of this analysis 20 percent is considered a hypothetical number, it is a plausible number. The 20 percent figure is based on overall estimates of juvenile mortality in the estuary, known mortality that can be attributed to specific threats, and professional judgment regarding the efficacy of the different management actions and the likelihood that constraints to their implementation can be overcome.

[4] Although the survival improvement targets are expressed in terms of numbers of natural-origin ESA-listed fish, this is simply to illustrate the potential benefits of actions, not to analyze differential benefits to natural-origin listed fish versus unlisted or hatchery-origin fish; what is important is the allocation of relative benefits among the management actions.

[5] Table 5-2 contrasts the difference between constrained and unconstrained implementation of an individual action, while Table 5-5 compares potential benefits across the entire set of actions. Given the two tables' different purposes, there is not a mechanistic relationship between them. However, there is a rough correlation between the potential benefits of constrained implementation in Table 5-2 and where an action falls in the relative rankings presented in Table 5-5.

protection projects reflects the value of avoiding the additional effort that would be required to restore functioning habitats lost because they were not protected.

Uses of the Survival Improvement Targets

The purpose of the survival improvement targets in Table 5-5 is to address a particular planning challenge in the estuary module: how to compare the potential benefits of management actions that are disparate in their scope and feasibility, especially when scientific information about the causes of salmonid mortality in the estuary is incomplete. In the absence of comprehensive scientific data, the targets provide a useful framework for evaluating the relative merits of different actions. However, survival improvement targets do not represent actual numbers of fish.

For example, it would be inappropriate to use the survival improvement targets to estimate total juvenile mortality in the estuary, attribute a level of mortality to a specific limiting factor or threat, or calculate "per-fish" costs of actions. Because the survival improvement targets are not scientifically derived, they have limited use for life-cycle modeling. On the other hand, the targets could serve as a starting point for life-cycle modeling in the absence of rigorous data.

It also would be unwise to predict specific outcomes of an action or suite of actions based solely on the survival improvement targets. Although it would be appropriate to use the targets to guide expenditures and the selection of individual projects that are consistent with the module's management actions, monitoring should accompany any implementation of those projects—to evaluate their effectiveness, test the assumptions underlying the targets, and provide a basis for refining them.

Because the survival improvement targets are a tool for comparing the relative benefits of actions, they are particularly useful in weighing the trade-offs involved in implementing some actions but not others, or implementing actions only partially. For example, in theory, if a certain action were implemented partially or not at all, the potential 20 percent gain in the number of wild, ESA-listed juveniles leaving the estuary and plume could not be achieved unless other actions were implemented to a greater extent than envisioned in the module, to compensate. Survival improvement targets provide a way of evaluating various scenarios for implementation. This is critical because the implementation of every action already is constrained (often significantly) and, in most cases, the opportunities to remove constraints and implement actions more fully are limited.

TABLE 5-5
Survival Improvement Targets Allocated to Management Actions[1]

Number	Action Description	Survival Improvement Target[1] with Constrained Implementation (numbers of wild, ESA-listed fish)			
		Ocean Type[1]	% of Total Improvement Target	Stream Type[1]	% of Total Improvement Target
CRE-01	Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	150,000	6%	100,000	6%
CRE-02	Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	90,000	4%	20,000	1%
CRE-03	Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	25,000	1%	20,000	1%
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	225,000	9%	125,000	7%
CRE-05	Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	5,000	<1%	5,000	<1%
CRE-06	Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	50,000	2%	15,000	<1%
CRE-07	Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities in the estuary.	8,000	<1%	10,000	<1%
CRE-08	Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	150,000	6%	100,000	6%
CRE-09	Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	400,000	16%	150,000	9%
CRE-10	Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	450,000	18%	100,000	6%
CRE-11	Reduce the square footage of over-water structures in the estuary.	25,000	1%	3,000	<1%
CRE-12	Reduce the effects of vessel wake stranding in the estuary.	55,000	2%	2,000	<1%

Number	Action Description	Survival Improvement Target[1] with Constrained Implementation (numbers of wild, ESA-listed fish)			
		Ocean Type[1]	% of Total Improvement Target	Stream Type[1]	% of Total Improvement Target
CRE-13	Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	140,000	6%	122,000	7%
CRE-14	Identify and implement actions to reduce salmonid predation by pinnipeds.	N/A[2]	N/A	1,034[2]	N/A
CRE-15	Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	20,000	<1%	15,000	<1%
CRE-16	Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	2,000	<1%	350,000	21%
CRE-17	Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	2,000	<1%	250,000	15%
CRE-18	Reduce the abundance of shad in the estuary.	5,000	<1%	5,000	<1%
CRE-19	Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	8,000	<1%	2,000	<1%
CRE-20	Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	50,000	2%	42,000	3%
CRE-21	Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	275,000	11%	72,000	4%
CRE-22	Restore or mitigate contaminated sites.	300,000	12%	142,000	8%
CRE-23	Implement stormwater best management practices in cities and towns.	65,000	3%	30,000	2%
	Total	2.5 million		1.68 million	

[1] Appendix B presents more information on how survival improvement targets were developed.

[2] The survival improvement targets are assigned for juvenile salmonids only. Although CRE-14 relates specifically to adult salmonids, the survival numbers for CRE-14 are not included in the 20 percent survival improvement targets for juvenile salmonids. The stream-type survival number is based upon an estimated 17 percent reduction in adult fish mortality applied to 2010 run-size information reported in U.S. Army Corps of Engineers (2010). Some mortality may be occurring as a result of pinniped predation on ocean-type juvenile salmon and steelhead. The extent to which this is occurring has not been established.

Evaluation of Management Actions: Costs and Schedule

Implementing recovery actions in the estuary will require a long-term commitment by many entities. In Tables 5-2 and 5-5, two approaches were used to portray the potential survival improvements associated with implementing actions. In Table 5-6, each action is broken down into one or more projects that can be considered elements of that action.

For some management actions, the first project involves conducting a study or assembling existing technical information. There are several reasons for this. In some cases, existing information about how to reduce the associated threat to salmonids is limited, and additional study is needed to identify and pilot-test possible actions to determine which ones would be most effective. This is particularly important when funds for implementing management actions are limited. Additionally, conducting a study or assembling technical information involves stakeholders who may have local knowledge about the threat or will be responsible for implementing projects. Lastly, studies and information gathering provide an opportunity to understand the constraints of management actions, to reexamine assumptions about what is and is not possible, and to explore the lengths to which, as a society, we are willing to go to implement actions that will contribute to the recovery of salmon and steelhead in the Columbia River basin. The intent of including studies and information gathering in the management actions, when appropriate, is not to postpone taking on-the-ground action but to ensure that any actions that are taken are truly effective, that stakeholders are involved in the process, and that important dialogue occurs about the value of reducing constraints and implementing management actions as fully as possible, even in situations where implementation is highly constrained.

The recovery plan module does not present a detailed list of projects waiting to be completed in the estuary. This is because in many cases, additional work is needed to develop complex, large-scale projects that will provide maximum benefit, or to work with landowners and other stakeholders to gain their support, or to understand the most effective avenue for implementation.

Table 5-6 provides cost estimates for each of the 23 actions in the estuary recovery plan module and a timeframe for their implementation. Each project in Table 5-6 has a corresponding unit and cost, and the project costs are summed to produce a total cost for each action. The costs identified in this section do not represent a detailed economic analysis; in fact, they are not economic costs in that they have not been discounted across time. Instead, the cost estimates are in constant dollars over a 25-year period. A 25-year implementation period was selected for several reasons. Many of the actions identified in the estuary module include project types that have never been implemented in the estuary, and it will take time to establish or modify programs to implement these projects; some will require new research and monitoring to guide their effective implementation. In addition, a 25-year implementation period will allow time to identify funding sources and build the landowner buy-in and project sponsor capacity needed to implement the 23 actions.

In most cases the costs listed in Table 5-6 are direct, incremental costs, meaning that they are (1) out-of-pocket costs that a public or private interest would pay to initiate and complete a management action, and (2) costs in addition to the baseline costs for existing programs and activities, which may or may not be focused on salmon recovery. This approach is consistent

with NMFS Northwest Regional Office guidance on cost estimates for ESA recovery plans. In some cases, distinctions between baseline and incremental costs are clear. For instance, reducing the abundance of shad (CRE-18) is an action that includes only incremental costs because it is a new action that has yet to be implemented in the estuary. Other actions, such as breaching, lowering, or relocating dikes (CRE-10), have been implemented in the estuary at a relatively modest scale. For such actions, the estuary recovery plan module cost estimate is still entirely incremental in that it identifies an additional level of effort needed to achieve the survival improvement targets identified later in this chapter.

Several of the 23 actions do contain some baseline costs, because in some cases these baseline costs represent a small fraction of the overall implementation cost of the action and it was deemed infeasible to separate out the incremental costs. In these cases, this fact is noted in Table 5-6 under the key assumptions for the individual management action. For example, Caspian tern management (CRE-16) is supported by an existing management plan, and some efforts are already under way to implement the action. The other two examples are managing pikeminnow and other piscivorous fish (CRE-13) and implementing stormwater best management practices (CRE-23). In these examples, programs are in place, but major portions of the estuary recovery plan module action have not been implemented to date. In addition, for one action—adjusting the timing, magnitude, and frequency of hydrosystem flows (CRE-4)—the primary costs are the costs of foregone power generation. Generally, recovery action cost estimates do not include such opportunity costs. We have included an estimate of such costs in this case because otherwise this action would have skewed the cost-effectiveness assessment in Chapter 7 (see Table 7-5) in a way that would preclude constructive dialogue about adjusting flows.

The cost estimates in Table 5-6 were developed by PC Trask & Associates, Inc., and reviewed by the Lower Columbia Fish Recovery Board, the Lower Columbia River Estuary Partnership, and NMFS. In addition, an economist at the NMFS Northwest Fisheries Science Center reviewed Chapter 5 and provided comments (although not a detailed evaluation of the costs). Lower Columbia River Estuary Partnership staff contributed substantively to cost estimates for actions for which the Estuary Partnership has some history of implementation. For example, the Estuary Partnership has funded multiple dike breaches (CRE-10), riparian protection projects (CRE-1), and off-channel protection/restoration projects (CRE-9). In other cases, where possible, experts knowledgeable about implementing similar actions were consulted. For example, staff from the NMFS Northwest Regional Office were consulted to estimate costs for managing pinnipeds (CRE-14).

In still other cases, a coarse estimate was established based on the component projects and assumptions about the feasibility of their implementation. These were generally cases in which the extent of on-the-ground actions could not be determined until certain scientific or technical questions have been answered more definitively through studies or information gathering (see, e.g., CRE-2, CRE-7, CRE-12, CRE-18). In these cases, costs of any assessment work were estimated, and then a coarse-scale, placeholder cost estimate was developed based on assumptions about the magnitude and nature of subsequent projects needed to implement the management action. It is expected that such cost estimates will be refined as more specific projects are defined.

Thus the cost estimates in Table 5-6 attempt to establish a realistic cost for recovery, but the precision with which costs can be estimated at this time is limited, and there is considerable

uncertainty in all the cost estimates. In Chapter 6, some additional costs are identified for research, monitoring, and evaluation activities (see Table 6-7).

The estuary recovery plan module addresses habitat conditions for all Columbia River basin ESUs during a single stage of their life cycle, but many additional management actions—including actions in the tributaries—will be needed to achieve recovery of any particular ESU. Because the management actions in the module are only a subset of all the actions needed for recovery of an ESU, the costs in Table 5-6 do not reflect the total costs to achieve recovery. Total costs for recovery are more appropriately represented in the recovery plans for each ESU, as these plans deal with multiple life stages for a specific ESU.

Each action in Table 5-6 includes a proposed schedule for implementation. The schedule is designed to place projects in a logical order and spread costs over a long period of time when possible. Costs are estimated over a 25-year span, with some projects being implemented once over a relatively short period and others continuing over the entire 25 years.

Other elements contained in Table 5-6 include the association of actions to specific geographical reaches, key assumptions about actions, a list of potential implementers,[6] notes that help explain how costs were developed, and a brief summary of some of the existing programs that address limiting factors identified in this recovery plan module. The summaries of existing programs are not exhaustive and are intended to emphasize that opportunities exist to build on existing programs to improve salmon and steelhead survival in the estuary. The relationship of actions to the eight geographic reaches and the plume helps to define the breadth of the action and may also indicate which jurisdictions may implement actions in the future. Key assumptions relate primarily to implementation and provide insight into the level of effort reflected in the action costs. Notes are specific information that helps clarify a particular unit or cost.

[6] The list of potential implementers is intended only to indicate entities that *may* have a role in implementation and to serve as a guide to begin discussion of implementation roles. It does not imply any budgetary, regulatory, or other responsibility for implementation.

TABLE 5-6
Estimated Cost and Schedule

Management Action CRE-1:

Protect intact riparian areas in the estuary and restore riparian areas that are degraded.

Project	Unit	Cost	Schedule
1. Educate landowners about the ecosystem benefits of intact riparian areas and the costs of degraded riparian areas.[1]	20 years @ $50,000/year	$1 million	2008 - 2028
2. Encourage and provide incentives for local, state, and Federal regulatory entities to maintain, improve (where needed), and enforce consistent riparian area protections throughout the lower Columbia region.[2]	10 years @ $500,000/year	$5 million	2008 - 2018
3. Actively purchase riparian areas from willing landowners in urban and rural settings when the riparian areas cannot be effectively protected through regulation or voluntary or incentive programs and (1) are intact, or (2) are degraded but have good restoration potential.	Rural: 3,500 acres at $5,000/acre[3] Urban: 100 acres at $75,000/acre	$25 million	2007 - 2031
4. Restore and maintain ecological benefits in riparian areas; this includes managing vegetation on dikes and levees to enhance ecological function and adding shoreline/instream complexity for juvenile salmonid refugia.	28 miles @ $250,000/mile	$ 7 million	2006 - 2031

Total costs: $38 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) New homes, businesses, and industry will increase with population growth in the basin. (2) Some intact riparian areas are not adequately protected. (3) Protecting intact riparian areas would be cheaper than restoring degraded areas. (4) Some degraded riparian areas could be restored and gain ecological function, with associated downstream benefits. (5) Comprehensive protection and restoration of riparian habitats would occur concurrently with population growth, which will continue at a high rate.

Existing efforts: Protection of riparian areas relies heavily on local governments; the content and implementation of their land use plans specifically for shoreline and floodplain protection will be key to this action. Multiple Federal and state resource agencies provide funding for land acquisition and restoration, and multiple entities such as land trusts and watershed councils actively acquire and restore lands in the lower river. The Division of State Lands in Oregon and the Department of Natural Resources in Washington own and/or regulate submerged and submersible lands. The Natural Resource Conversation Service and conservation districts provide technical assistance to private landowners. Where water quality issues (such as toxic or conventional contaminants) are involved, agencies such as Washington's Department of Ecology and Oregon's Department of Environmental Quality may provide additional support.

Potential implementers:

- U.S. Army COE
- BPA
- WA Dept. of Fish & Wildlife
- OR Dept. of Fish & Wildlife
- Cities\Counties
- Port districts
- Conservation districts
- Columbia Land Trust
- The Wetlands Conservancy
- The Nature Conservancy
- Ducks Unlimited
- Natl. Fish & Wildlife Foundation
- Tribes
- OR Watershed Enhance. Bd.
- Salmon Recovery Fund. Bd.
- Lower Col. River Est. Partnership
- National Marine Fisheries Service
- Col. River Estuary Study Taskforce
- Utility districts
- Watershed councils

Notes:

[1] Projects CRE-1.1 and CRE-9.1 both call for outreach efforts. Outreach efforts for these two actions will be combined in a single outreach program whose costs will be shared.

[2] Projects CRE-1.2 and CRE-9.2 both call for incentives for local, state, and Federal entities to maintain, improve, and enforce regulatory protections. Given their similarities, activities for CRE-1.2 and CRE-9.2 could be coordinated or combined into one effort.

[3] Acreage amounts are 25-year targets that depend on willing sellers and funding.

Management Action CRE-2:

Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.

Project	Unit	Cost	Schedule
1. Conduct a reservoir heating study to determine the extent of the issue and identify hydrosystem operational changes (including design) that would reduce effects and/or mitigate downstream temperature issues.	1 study	$2.5 million	2007 - 2013
2. Implement hydrosystem operational changes to reduce temperature effects; if no change is possible, mitigate effects through restoration of tributary riparian areas.	25 years @ $700,000/year[1]	$17.5 million	2010 - 2032

Total costs: $20 million

Geographical priority: Reaches A-H and the plume.

Key assumption: (1) Either there is potential to alter management practices in the hydrosystem to reduce flow temperatures or a commensurate level of mitigation in tributaries would reduce temperatures in the estuary. (2) If temperatures continue to increase above 19° C, the estuary could become completely lethal for salmonids and other native species.

Existing efforts: The U.S. Environmental Protection Agency (EPA) is concerned about water temperature issues in the Columbia and Snake River system and their impacts on ecosystem health, particularly in light of global climate change. Oregon and Washington have listed the Columbia River as impaired for temperature under the Clean Water Act Section 303(d). In 2003, EPA issued a Preliminary Draft Total Maximum Daily Load (TMDL) for the mainstem Columbia River, but the TMDL has not been finalized. EPA plans to work with the states of Oregon and Washington to revisit the TMDL and decide how to address mainstem Columbia River temperature issues.

Potential implementers:

- Bonneville Power Administration
- U.S. Army Corps of Engineers
- Utility districts
- Oregon Department of Environmental Quality
- Washington State Department of Ecology

Notes:

[1] Assumes that some level of improvement is possible but that the level of possible improvement is likely to be minor because of complexities of the hydrosystem; assumes that mitigation will be needed to offset temperature increases.

Management Action CRE-3:

Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.

Project	Unit	Cost	Schedule
1. Explore technical options and develop policy recommendations on instream flows.	5 years @ $1 million/year	$5 million	2007 - 2015
2. Implement instream flow regulations in accordance with the policy recommendations in Project No. 1.	5 years @ $1 million/year	$5 million	2015 - 2023

Total costs: $10 million

Geographical priority: Reaches A–H and the plume.

Key assumptions: (1) Demand for water for human use will grow as the human population in the basin increases. (2) Additional instream flows in the Columbia River mainstem and tributaries could be established through the efforts of affected parties basinwide. (3) Establishing an instream flow regime would protect flows entering the estuary in the future. (4) An instream flow regime would help develop additional water conservation efforts and guide land use development in concert with water availability. (5) Protecting and/or enhancing estuary instream flows would require coordination with the Columbia River hydrosystem to achieve lasting results.

Existing efforts: Resource agencies can request instream flows to support fish and wildlife, water quality, and recreational needs in tributaries entering the estuary. In Oregon, the Department of Environmental Quality, Department of Fish and Wildlife, and Department of Parks & Recreation are authorized to request instream water rights to support their statutory obligations. The Oregon Water Resources Department and Commission review these requests and establish instream water rights. In Washington, the Department of Ecology established instream flows in all of the major Washington tributaries entering the estuary. Tributary flows also are often addressed in the relicensing processes for hydropower facilities regulated by the Federal Energy Regulatory Commission. Over the past decade, many tributary hydropower facilities (e.g., the Cowlitz River Project and the Lewis River Hydroelectric Projects) have been relicensed. Establishing an instream flow regime for the estuary would involve many Federal and state agencies and would require an organizational framework that currently does not exist.

Potential implementers:

- States (Washington, Oregon, Idaho, Montana)
- Cities and counties
- Irrigators
- Tributary hydropower utilities
- U.S. Army Corps of Engineers
- Bonneville Power Administration
- U.S. Bureau of Reclamation

Management Action CRE-4:

Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.

Project	Unit	Cost	Schedule
1. Conduct a flood study to determine the risks and feasibility of returning to more normative flows in the estuary.	2 years @ $500,000/year	$1 million	2009 - 2010
2. Conduct a study to determine the habitat effects of increasing the magnitude and frequency of hydrosystem flows (i.e., how much access of river to off-channel habitats would increase).	3 years @ $500,000/year	$1.5 million	2009 - 2011
3. Conduct additional studies to determine the extent of other constraints, including international treaties, systemwide fish management objectives, and power management.	4 years @ $500,000/year	$2 million	2010 - 2014
4. Make policy recommendations to action agencies on flow, taking into consideration beneficial estuary flows, flood management, power generation, irrigation, water supply, fish management, and other interests.	25 years @ $100,000/year	$2.5 million	2010 - 2035
5. Implement modified estuary flow regime annually in concert with other interests, including hydroelectric, flood control, and water withdrawals.	25 years @ $1.5 million/year[1]	$37.5 million	2011 - 2036

Total costs: $44.5 million

Geographical priority: All reaches (A-H) and the plume.

Key assumptions: (1) Even incremental changes in the magnitude and frequency of hydrosystem flows would improve salmonid habitat opportunity and food inputs, which would have benefits throughout the ecosystem. (2) Studies of flood risk and the effect of flow changes on estuarine habitat would provide data useful in modifying hydrosystem operations to benefit salmonids. (3) Studies of constraints to implementation would identify some obstacles that could be overcome. (4) Small to moderate changes in the magnitude, frequency, and timing of flows would improve sediment transport-related habitat opportunity in the estuary. (5) Increased spring freshets would yield greater sediment transport-related benefits than would other flow modifications.

Existing efforts: Large-scale efforts to adjust flows entering the estuary and return hydrology to more historical conditions have not yet begun because of the level of uncertainty regarding potential scenarios for adjusting the timing and volume of flow and the associated habitat benefits. Significant efforts have been undertaken by Bonneville Power Administration, the U.S. Army Corps of Engineers, and the U.S. Bureau of Reclamation to manage the hydrosystem for passage of juvenile salmonids. In addition, flows entering the estuary currently are managed to minimum seasonal flows to protect chum redds in the mainstem below Bonneville Dam.

Potential implementers:

- Bonneville Power Administration
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation

Notes:

[1] Assumes $1.5 million per year cost of decreased hydrosystem generation revenues associated with minor and incremental adjustments to flows; also assumes that the flood risk associated with beneficial estuary flows does not increase significantly. The $1.5 million per year cost is included primarily as an indicator that there would be some foregone revenues even with minor changes in the flow regime. Specific costs will be evaluated during implementation as specific scenarios for modifying flows are developed and considered.

Management Action CRE-5:

Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.

Project	Unit	Cost	Schedule
1. Identify the effects of reservoir sediment entrapment on economic and ecological processes; this includes effects on ship channels, turning basins, port access, jetty activities, and habitat availability.	1 study	$2 million	2008 - 2011
2. Develop a regionwide sediment plan for the estuary to address salmonid habitat-forming processes.	10 years @ $100,000/year	$1 million	2006 – 2031
3. Implement projects recommended in the plan to mitigate the effects of sediment entrapment.	5 projects @ $1 million/project	$5 million	2010 - 2020

Total costs: $8 million

Geographical priority: Reaches A-H and the plume.

Key assumptions: (1) Sediment entrapment in reservoirs will continue. (2) Sediment entrapment has negative effects, both ecologically and economically. (3) The extent of these effects warrants exploration and implementation of potential mitigation measures. (4) Studying potential mitigation measures would identify some actions that would be effective and could be implemented. (5) Synergistic ecological effects may be realized as a result of implementing CRE-5 and CRE-6, which could increase sediment inputs into the estuary (CRE-5) and optimize beneficial uses of dredged materials (CRE-6).

Existing efforts: The Lower Columbia Solutions Group, a bi-state organization made up of local, state, and Federal governmental and non-governmental stakeholders, was formed by the governors of Washington and Oregon to address activities related to the disposal of dredged materials in the estuary. Developing a sediment budget is one of the activities of the Lower Columbia Solutions Group; it is likely that this sediment management budget will include the effects of reservoir sediment entrapment.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration

Management Action CRE-6:

Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.

Project	Unit	Cost	Schedule
1. Develop a regionwide sediment plan for the estuary and littoral cell.	See CRE-5.	See CRE-5.	See CRE-5.
2. Identify and implement dredged material beneficial use demonstration projects, including the notching and scrape-down of previously disposed materials and placement of new materials for habitat enhancement and/or creation.	100 acres @ $10,000/ acres	$1 million	2006 - 2012
3. Dispose of dredged materials using techniques identified through the demonstration projects and regionwide planning.	500 acres @ $10,000/acre[1]	$5 million	2008 - 2033

Total costs: $6 million

Geographical priority: Reaches A, B, C, and G, the Lower Willamette reach, and the plume and nearshore.

Key assumptions: (1) Dredging activities will continue or increase over time. (2) Opportunities to beneficially use dredged materials for habitat can be identified. (3) Beneficial use of dredged material would have a positive effect on sediment transport and habitat-forming processes in the estuary, plume, and littoral cell.

Existing efforts: Several agencies and organizations are actively engaged in the evaluation of dredged material for ecosystem-based beneficial uses. The Lower Columbia Solutions Group currently is focused on reducing the disposal of dredged materials in open waters off the mouth of the Columbia River in favor of supplementing the nearshore littoral cell with sediments. The Portland District of the U.S. Army Corps of Engineers is exploring tidal wetland development in the estuary based on an assessment of wetlands that have formed accidentally where dredged materials were placed historically. The Port of Portland also is exploring the use of dredged materials for potential development of subtidal habitats.

Potential implementers:

- U.S. Army Corps of Engineers
- Port districts
- Cities
- Lower Columbia River Solutions Group
- Oregon Department of Environmental Quality
- Oregon Department of State Lands
- Oregon Department of Fish and Wildlife
- Oregon Department of Land Conservation and Development
- Washington Department of Ecology
- Washington Department of Fish and Wildlife

Notes:

[1]Unit cost is funding to pay for activities beyond the minimum required by law, to achieve regional-scale ecosystem benefits.

Management Action CRE-7:

Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

Project	Unit	Cost	Schedule
1. Identify and evaluate dredge operation techniques designed to reduce entrainment and other habitat effects.	1 project	$500,000	2008 - 2010
2. Initiate demonstration projects designed to test and evaluate dredge operations.	5 projects @ $200,000/project	$1 million	2009 - 2012
3. Implement best management techniques.	10 years @ $250,000/year[1]	$2.5 million	2011 – 2036
4. Study the effects of entrainment of juvenile salmonids from ship ballast water intake.	1 study @ $250,000	$250,000	2009 – 2011
5. Implement a demonstration project to evaluate the feasibility of reducing entrainment of juvenile salmonids from ship ballast intake.	1 project @ $250,000	250,000	2012 -- 2015

Total costs: $4.5 million

Geographical priority: Reaches A, B, C, D, E, F, G, and the Lower Willamette reach.

Key assumptions: (1) Improved best management practices can be identified that would help reduce the impact of dredging. (2) Mitigation activities would help offset changes to the estuary caused by dredging.

Existing efforts: The U.S. Army Corps of Engineers and ports in the lower Columbia River have studied the effects of entrainment on aquatic species and have implemented actions to reduce negative effects. Screening and other ship ballast activities to decrease entrainment of juvenile salmonids have been implemented.

Potential implementers:

- U.S. Army Corps of Engineers
- Port districts
- Private entities, such as ports and sand and gravel dredgers
- Counties and cities

Notes:

[1]This is an estimate of the incremental cost above permitted dredge activities. Cost may vary significantly depending on site-specific conditions.

Management Action CRE-8:

Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.

Project	Unit	Cost	Schedule
1. Inventory, assess, and evaluate in-channel pile dikes for their economic value and their negative and positive impacts on the estuary ecosystem; develop working hypotheses for removal or modification.	1 plan	$250,000	2007 - 2009
2. Implement demonstration projects designed to test working hypotheses and guide future program priorities.	4 pile dike removal projects @ $125,000/project	$500,000	2009 - 2010
3. Remove or modify priority pilings and pile dikes.	25 years @ $1 million/year	$25 million	2008 - 2033
4. Monitor the physical and biological effects of pile dike removal and/or modification.	10 years @ $150,000/year	$1.5 million	2010 - 2020

Total costs: $27.25 million

Geographical priority: Reaches A – H and the Lower Willamette reach.

Key assumption: (1) Many pilings, pile dikes, and similar structures could be removed or modified without compromising the shipping channel or protection of property. (2) Over time, the removal or modification of superfluous pile dikes would improve conditions for salmonids and the ecosystem.

Existing efforts: This action was incorporated into the 2008 Federal Columbia River Power System Hydropower Biological Opinion (BiOp) Remand as Reasonable and Prudent Alternative 38: Piling and Dike Removal Program. A project team composed of the Lower Columbia River Estuary Partnership, Bonneville Power Administration, and the U.S. Army Corps of Engineers is working to develop a strategic plan to remove, modify, or retain pile structures within the mainstem lower river. (Modification could include adding large wood to make complex habitat, for example.) The program currently is funded at a level of $1 million per year and is expected to be funded through 2018 if the program proves successful in providing benefits to salmonids.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- Washington Department of Natural Resources
- Washington Department of Fish and Wildlife
- Oregon Department of Fish and Wildlife
- Oregon Department of Lands
- Lower Columbia River Estuary Partnership
- Counties and cities
- Tribes

Management Action CRE-9:

Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.

Project	Unit	Cost	Schedule
1. Educate landowners about the ecosystem benefits of protecting and stewarding intact off-channel areas and the costs of restoring degraded areas.[1]	(See CRE-1.1)	$500,000	2008 - 2028
2. Encourage and provide resources for local, state, and Federal regulatory entities to maintain, improve (where needed), and consistently enforce habitat protections throughout the lower Columbia region.[2]	10 years @ $500,000 million/year	$5 million	2008 - 2018
3. Actively purchase off-channel habitats in urban and rural settings that (1) cannot be effectively protected through regulation, (2) are degraded but have good restoration potential, or (3) are highly degraded but could benefit from long-term restoration solutions.[3]	Rural: 5,000 acres at $3,000/acre Urban:150 acres at $100,000/acre	$30 million	2007 – 2031
4. Restore degraded off-channel habitats with high intrinsic potential for increasing habitat quality.	Rural: 6,000 acres at $5,000/acre Urban: 500 acres at $5,000/acre	32.5 million	2007 - 2031

Total costs: $68 million

Geographical priority: Reaches A, B, C, and G and the Lower Willamette reach.

Key assumptions: (1) Protection opportunities can be increased over the next decade through public awareness, educational, regulatory, and acquisition programs. (2) Protection of off-channel habitats is less expensive than restoration. (3) High-quality off-channel habitats offer benefits to salmonids that cannot be provided in other ways. (4) Protection will be needed to offset increasing threats resulting from human population increases in the estuary and basin. (5) Restoring off-channel habitat function in the estuary is critical to ecosystem processes. (6) Restoring off-channel habitats enhances juvenile salmonid growth by increasing access to food sources and provides refugia from high flows and predation.

Existing efforts: Protection of off-channel habitats relies heavily on local governments; the content and implementation of their land use plans specifically for shoreline and floodplain protection will be key to this action. Multiple Federal and state resource agencies provide funding for land acquisition and restoration, and multiple entities such as land trusts and watershed councils actively acquire and restore lands in the lower river. The Division of State Lands in Oregon and the Department of Natural Resources in Washington own and/or regulate submerged and submersible lands. The Natural Resource Conversation Service and conservation districts provide technical assistance to private landowners. Where water quality issues (such as toxic or conventional contaminants) are involved, agencies such as Washington's Department of Ecology and Oregon's Department of Environmental Quality may provide additional support. The Lower Columbia River Estuary Partnership's Habitat Restoration Program largely is directed toward this action, CRE-1, and CRE-10. Organizations such as the Columbia Land Trust and the Columbia River Estuary Study Taskforce are actively involved in off-channel restoration activities.

Potential implementers:

- U.S. Army COE
- BPA
- Columbia Land Trust
- The Wetlands Conservancy
- Ducks Unlimited
- Col. River Est. Study Taskforce
- The Nature Conservancy
- Lower Col. River Est. Partnership
- Watershed councils
- OR Watershed Enhancement Bd.
- OR Dept. of Fish and Wildlife
- WA Dept. of Ecology
- Port districts
- Cities
- Conservation districts
- Other special districts
- Tribes

Notes:

[1] Projects CRE-1.1 and CRE-9.1 both call for outreach efforts. Outreach efforts for these two actions will be combined in a single outreach program whose costs will be shared.

[2] Projects CRE-1.2 and CRE-9.2 both call for incentives for local, state, and Federal entities to maintain, improve, and enforce regulatory protections. Given their similarities, activities for 1.2 and 9.2 could possibly be coordinated or combined into a single effort.

[3] Assumes purchases are made over a 25-year period with willing sellers.

Management Action CRE-10:

Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.

Project	Unit	Cost	Schedule
1. Breach, lower the elevation of, or relocate dikes and levees; create and/or restore tidal marshes, shallow-water habitats, and tide channels.	5,000 acres[1] @ $10,000/acre	$50 million	2006 - 2031
2. Remove tide gates to improve the hydrology between wetlands and the channel and to provide juveniles with physical access to off-channel habitat; use a habitat connectivity index to prioritize projects.	2,000 acres[1] @ $10,000/acre	$20 million	2006 - 2031
3. Upgrade tide gates or perched culverts where (1) no other options exist, (2) upgraded structures can provide appropriate access for juveniles, and (3) ecosystem function would be improved over current conditions.	1,000 acres[1] @ $5,000/acre	$5 million	2006 - 2031

Total costs: $75 million

Geographical priority: Reaches A, B, C, E, F, and G and the Lower Willamette reach.

Key assumptions: (1) Additional opportunities to restore off-channel habitats can be developed through long-term outreach and improved landowner relationships. (2) Restoration of sites, including elevation restoration, would yield broad-scale ecosystem benefits over time. (3) A habitat connectivity index would help target efforts toward the projects that would provide the greatest benefits. (4) Restoration of highly degraded sites may be necessary to yield long-term benefits.

Existing efforts: Multiple Federal and state resource agencies provide funding for restoration activities, including improving hydrologic conditions and access for juvenile salmonids. In the estuary, the U.S. Army Corps of Engineers, Columbia River Estuary Taskforce, and Columbia Land Trust have significant experience breaching dikes or retrofitting tide gates. Other entities, including watershed councils, conservation districts, and private firms, also have experience but sometimes lack sufficient technical and infrastructure capacity. Extensive community outreach and long-term relationship building will be needed to implement this action. The Lower Columbia River Estuary Partnership's Habitat Restoration Program largely is directed toward this action, CRE-1, and CRE-9.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- U.S. Fish and Wildlife Service
- Oregon Watershed Enhancement Board
- Oregon Department of Fish and Wildlife
- Columbia Land Trust
- Columbia River Estuary Study Taskforce
- Salmon Recovery Funding Board
- Conservation districts
- Other districts
- Cities
- Counties
- Lower Columbia River Estuary Partnership
- Lower Columbia Fish Recovery Board
- Watershed councils
- Tribes

Notes:

[1]Acreage equals amount of affected area. Costs include those associated with protecting other land uses from renovated hydrology (i.e., moving dikes and levees).

Management Action CRE 11:

Reduce the square footage of over-water structures in the estuary.

Project	Unit	Cost	Schedule
1. Inventory over-water structures and develop a GIS layer with detailed metadata files.	2 projects @ $150,000/project	$300,000	2007 - 2009
2. Initiate a planning process to evaluate existing and new over-water structures for their economic, ecological, and recreational value.	2 phases[1] @ $100,000/phase	$200,000	2009 - 2013
3. Remove or modify over-water structures to provide beneficial habitats.	10 projects @ $500,000/project[2]	$5 million	2012 - 2037
4. Establish criteria for new permit applications to consider the cumulative impacts of over-water structures.	1 project	$300,000	2008 - 2010

Total costs: $5.8 million

Geographical priority: Reaches D and G and the Lower Willamette reach.

Key assumptions: (1) Over-water structures pose some threat to salmonids. (2) A fair number of over-water structures are no longer in use or have relatively minor value to owners. (3) An inventory of over-water structures would aid in assessing individual structures' economic, ecological, and recreational value.

Existing efforts: Over-water structures are regulated by specific sections of the Federal Clean Water Act, state statute, or both. These laws are administered by Federal agencies (U.S. Army Corps of Engineers, U.S. Environmental Protection Agency) or state agencies (Oregon Department of Environmental Quality, Oregon Division of State Lands, Oregon Department of Land Conservation and Development, Washington Department of Ecology, and Washington Department of Natural Resources). The Lower Columbia River Estuary Partnership created a shoreline condition inventory that maps all over-water structures using GIS. Currently, there are no targeted efforts to remove over-water structures in the estuary.

Potential implementers:

- U.S. Army Corps of Engineers
- Cities
- Washington Department of Natural Resources
- Oregon Department of Land Conservation and Development
- Oregon Department of State Lands

Notes:

[1]The first phase is technical and the second phase is policy.

[2]A project is defined as a set of structures that have been identified for removal; cost is level of effort.

Management Action CRE-12:

Reduce the effects of vessel wake stranding in the estuary.

Project	Unit	Cost	Schedule
1. Analyze factors contributing to ship wake stranding to determine potential approaches to reducing mortality in locations where juveniles are most vulnerable. Design and implement demonstration projects and monitor their results.	1 study @ $1 million	$1 million	2007 - 2010
2. Implement projects identified in Project No. 1 that are likely to result in the reduction of ship wake stranding events.	12 projects @ $1 million/project[1]	$12 million	2011 - 2026

Total costs: $13 million

Geographical priority: Reaches C, D, E, and F.

Key assumptions: (1) Vessel wake stranding is a significant issue for ocean- and stream-type salmonids employing the fry life history strategy in the estuary.

Existing efforts: The U.S. Army Corps of Engineers initiated a two-phase study on vessel wake stranding associated with the channel deepening project. Phase 1 was completed in 2006 as part of the channel deepening project. Results could be used to design follow-up studies analyzing factors that contribute to ship wake stranding. In addition, in 2008 the Port of Vancouver completed a study designed to estimate the total acres of estuary shoreline (downstream of the port) that may contribute to ship wake stranding.

Potential implementers:

- U.S. Army Corps of Engineers
- Columbia River pilots
- Ports
- US Coast Guard
- River and bar pilots

Notes:

[1] This is a level-of-effort cost approach that will require information generated in Projects No. 1 and 2.

Management Action CRE-13:

Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.

Project	Unit	Cost	Schedule
1. Monitor the abundance levels of pikeminnow, smallmouth bass, walleye, and channel catfish.	5 monitoring events @ $100,000/event (every 5 years)	$500,000	2006 - 2031
2. Implement actions as necessary to prevent population growth (i.e., modify habitat)[1]; increase the northern pikeminnow bounty program in the estuary.	25 years @ $500,000/year	$12.5 million	2006 - 2031

Total costs: $13 million

Geographical priority: Reaches D, E, F, G, and H and the Lower Willamette reach.

Key assumption: Management techniques would maintain populations at levels that would maintain or reduce predation impacts to salmonids. A pikeminnow management plan exists and is being implemented. Costs associated with this action are partly covered as a baseline cost. Costs associated with managing other piscivorous fish, including smallmouth bass, walleye, and channel catfish, are entirely incremental costs.

Existing efforts: Bonneville Power Administration funds the Northern Pikeminnow Sport Reward Fishery Program whereby anglers receive $4 to $8 for every qualifying northern pikeminnow 9 inches or longer returned to a registration station. Since 1990, more than 3.1 million northern pikeminnow have been removed from the Snake and Columbia rivers as a result of this program. The annual budget for the Northern Pikeminnow Management Program has varied from $2.0 to $6.4 million, with an average of about $3.0 million basinwide.

Potential implementers:

- U.S. Army Corps of Engineers
- Washington Department of Fish and Wildlife
- Oregon Department of Fish and Wildlife
- Bonneville Power Administration
- National Marine Fisheries Service

Notes:

[1] It is unknown whether projects will be needed to manage warm-water fish. In some cases, there may be warm-water habits close to juvenile habitat, in which case site-specific action would be required.

Management Action CRE-14:

Identify and implement actions to reduce salmonid predation by pinnipeds.

Project	Unit	Cost	Schedule
1. Expand Federal and state activities at Bonneville Dam to test non-lethal and potentially lethal methods of reducing pinniped populations throughout the estuary. This includes efforts to manage pinnipeds through the Marine Mammal Protection Act.	5 years @ $500,000/year	$2.5 million	2007 - 2011
2. Implement actions likely to reduce pinniped predation on adult salmonids.	25 years @ $500,000/year[1]	$12.5 million	2007 - 2032

Total costs: $15 million

Geographical priority: Reaches A-H (especially H).

Key assumptions: (1) Mortality from pinnipeds throughout the lower Columbia River may be a larger source of salmonid mortality than previously understood. (2) Further study would clarify the impact of pinniped predation on salmonids; studies by the U.S. Army Corps of Engineers at Bonneville Dam represent a good start on this task. (3) Mortality from pinniped predation could be reduced through non-lethal and lethal methods. (4) The Marine Mammal Protection Act could be modified over time to allow more tools for managing pinnipeds in the estuary. In 2008, NMFS granted authority under Section 120 of the Marine Mammal Protection Act to the states of Oregon, Washington, and Idaho to intentionally take, by lethal methods, individually identifiable California sea lions that prey on Pacific salmon and steelhead at Bonneville Dam (Federal Register 2008).

Existing efforts: The National Marine Fisheries Service, Oregon and Washington, the U.S. Army Corps of Engineers, and Bonneville Power Administration have initiated efforts to manage pinnipeds, primarily at Bonneville Dam. As of 2010, efforts included both lethal and non-lethal methods sanctioned under Section 120 of the Marine Mammal Protection Act.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- National Marine Fisheries Service
- Columbia River Inter-Tribal Fish Commission
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Notes:

[1] Units are years; given the constraints to this action, it is likely that ongoing efforts to prevent predation will continue over the next 25 years.

Management Action CRE-15:

Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.

Project	Unit	Cost	Schedule
1. Increase public awareness of exotic plant species and proper stewardship techniques.[1]	10 years @ $100,000/year	$1 million	2008 – 2018
2. Inventory exotic plant species infestations and develop a GIS layer with detailed metadata files.	5 phases @ $200,000/phase	$1 million	2007 – 2012
3. Implement projects to address infestations on public and private lands.	10,000 acres @ $1,000/acre	$10 million	2008 – 2028
4. Monitor infestation sites.	20 years @ $25,000/year	$500,000	2010 - 2030

Total costs: $12.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach).

Key assumptions: (1) Aquatic invasive plants have a negative effect on the estuary ecosystem and affect juvenile salmonids by altering habitat and causing food webs to deteriorate. (2) Additional information is needed on the location, extent, and type of infestations and their effects on the estuary ecosystem. (3) Because introductions of invasive plants can permanently alter the estuary ecosystem, prevention activities are crucial. (4) Education, outreach, and monitoring would help prevent further introductions of invasive plants.

Existing efforts: The fish and wildlife departments of Oregon and Washington have management responsibilities for fish and wildlife, including the control of non-indigenous species. The Washington Department of Fish and Wildlife has developed an Aquatic Non-indigenous Species Management Plan. The Pacific States Marine Fisheries Commission promotes interstate communication and facilitates the coordination of aquatic non-indigenous species activities on the West Coast. The Oregon and Washington Sea Grant programs combined to form the Northwest Marine Invasive Species Team to raise the level of awareness about the threats of invasive species. The Invasive Alien Species Executive Order at the Federal level created the Invasive Species Council and directed development of an Invasive Species Management Plan. Multiple Federal and state resource agencies provide funding for restoration projects that remove exotic invasive plants, and entities such as land trusts and watershed councils actively eradicate exotic native plants and plant native species in the lower river. Noxious weed control entities exist in Oregon and Washington to help educate landowners and control invasive plants.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- US Fish and Wildlife Service
- State agencies
- Conservation districts
- Noxious weed districts
- Counties
- Cities
- Tribes
- Watershed councils
- Lower Columbia River Estuary Partnership
- The Nature Conservancy
- Landowners

Notes:

[1]This project is recommended for upstream mainstem and tributaries, but the costs presented here are for activities in the estuary only. Many exotic plants have established themselves upstream and represent a constant downstream threat to the estuary.

Management Action CRE-16:

Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.

Project	Unit	Cost	Schedule
1. Enhance or create tern nesting habitat at alternative sites in Washington, Oregon, and California.	3 sites @ $1 million/site	$3 million	2008 - 2012
2. Reduce tern nesting habitat on East Sand Island from 6 acres to 1 to 1.5 acres.	1 project @ $4.5 million/project	$4.5 million	2007 - 2010
3. Monitor the regional tern population.	25 years @ $100,000/year	$2.5 million	2010 - 2035

Total costs: $10 million

Geographical priority: Reaches A and B.

Key assumption: Ongoing and new management actions directed to Caspian tern nesting habitat would continue to reduce salmonid mortality from tern predation. A management plan exists and is being implemented. Costs associated with this action are partially covered as a baseline cost.

Existing efforts: The U.S. Army Corps of Engineers has recently constructed alternative habitat for Caspian terns outside of the estuary. The Corps also funds studies assessing Caspian tern population levels and predation rates on juvenile salmonids. These studies track terns along the West Coast to determine whether management actions in the lower river result in redistribution of terns elsewhere along the West Coast. A predatory bird Web site (www.birdresearchnw.org) keeps the public and others informed on the status of management plans and research.

Potential implementers:

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Management Action CRE-17:

Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.

Project	Unit	Cost	Schedule
1. Identify, assess, and evaluate methods of reducing double-crested cormorant abundance numbers.	1 multiphase study	$1 million	2007 - 2011
2. Implement demonstration projects resulting from Project No. 1 (i.e., decoys and audio playback methods).	5 pilot projects @ $500,000/project	$2.5 million	2010 - 2015
3. Implement projects resulting in reduced predation by cormorants.[1]	10 years @ $700,000/year	$7 million	2013 - 2023

Total costs: $10.5 million

Geographical priority: Reaches A and B.

Existing efforts: The U.S. Army Corps of Engineers funds studies assessing cormorant population levels and predation rates on juvenile salmonids. These studies track cormorants along the West Coast to determine whether management actions in the lower river result in redistribution elsewhere along the West Coast. A predatory bird Web site (www.birdresearchnw.org) keeps the public and others informed on the status of management plans and research.

Potential implementers:

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Notes:

[1]This is a level-of-effort cost estimate; efforts to manage cormorants in the estuary are significantly lagging Caspian tern management efforts and will likely be more difficult to implement.

Management Action CRE-18:

Reduce the abundance of shad in the estuary.

Project	Unit	Cost	Schedule
1. Organize existing technical information about shad and identify data gaps and potential control methods.	2 phases @ $250,000/phases	$500,000	2007 - 2011
2. Implement demonstration projects to evaluate effective shad management methods.	4 projects @ $500,000/project	$2 million	2008 - 2015
3. Implement shad population management techniques.[1]	10 years @ $250,000/year	$2.5 million	2010 - 2015
4. Monitor and evaluate shad management techniques.	10 years @ $50,000/year	$500,000	2011 - 2021

Total costs: $5.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Shad have negative affects on salmonids in the estuary. (2) Additional research would shed light on how shad affect salmonids and suggest new management techniques. (3) New management techniques would be unlikely to cause significant change.

Existing efforts: The U.S. Geological Survey, with funding from Bonneville Power Administration, is studying the presence of American shad in the Columbia River throughout the year, assessing shad diet trends, and PIT tagging up to 1,000 adult pre-spawn shad in the estuary to examine their time of arrival at dams using PIT tag detection technologies in fishways.

Potential implementers:

- U.S. Army Corps of Engineers
- U.S. Geological Survey
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Notes:

[1]This is a level-of-effort cost estimate; currently there are no plans to manage shad abundance levels in the Columbia River.

Management Action CRE-19:

Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.

Project	Unit	Cost	Schedule
1. Assemble existing technical information on introduced aquatic invertebrates in the estuary and develop a plan for managing existing infestations and preventing new infestations.	2 phases @ $250,000/phase	$500,000	2007 - 2010
2. Implement recommendations from the plan for managing existing infestations and preventing new infestations (Project No. 1, above).[1]	5 projects @ $500,000/project	$2.5 million	2008 – 2013

Total costs: $3 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Ship ballast practices could be improved to help prevent further degradation of the estuary ecosystem. (2) Additional research would help scientists understand the effects of exotic invertebrates on the ecosystem. (3) Because the effects of exotic invertebrates on the ecosystem usually cannot be reversed, it is important to prevent introductions when possible.

Existing efforts: Following the direction of the 2007 Oregon Legislature, the Shipping Transport of Aquatic Invasive Species Task Force was convened in 2008 to examine how Oregon can better handle aquatic invasive species coming into the state via shipping activities. The task force compiled a report outlining various aspects of preventing the introduction of aquatic invasive species from shipping-related pathways. The report also recommended steps that the Oregon Department of Environmental Quality, working with other agencies and the shipping industry, can take to bolster efforts to halt the arrival and spread of aquatic invasive species that degrade existing ecosystems and displace native species.

Likewise, the Aquatic Nuisance Species Unit of the Washington Department of Fish and Wildlife (WDFW) has implemented the Washington State ballast water program since 2000. This program receives state funds for program management, vessel report tracking, and vessel inspection efforts. Two vessel inspectors stationed in Puget Sound and the SW/Columbia River regions target high-risk vessels for boarding and ballast sampling. Washington established discharge standards that, as of 2009, had not yet been implemented.

In 2008, the Environmental Protection Agency issued a Vessel General Permit (VGP) as part of the National Pollutant Discharge Elimination System under the Federal Water Pollution Control Act. This permit is intended to regulate discharges resulting from the normal operation of all non-recreational vessels 79 feet or longer. In addition, the ballast water discharge provisions apply to any non-recreational vessel of less than 79 feet and commercial fishing vessels of any size discharging ballast water, and require adoption of best management practices for discharges. Currently, the VGP regulations adopt U.S. Coast Guard ballast water exchange requirements and coastal exchange requirements for domestic voyages along the West Coast but do not include ballast water treatment technology. Under the Clean Water Action Section 401 certification requirements, states can adopt more stringent conditions than the VGP in their certifications if so needed to meet requirements of either the Clean Water Act or state law.

Potential implementers:

- Port districts
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife
- U.S. Fish and Wildlife Service
- Oregon Department of Agriculture
- Washington State Department of Agriculture
- Portland State University
- Oregon State Marine Board
- Washington State Parks and Recreation Commission
- Oregon Department of Environmental Quality

Notes:

[1]This is a level-of-effort cost estimate.

Management Action CRE-20:

Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.

Project	Unit	Cost	Schedule
1. Educate landowners, businesses, and other users about practices to reduce usage and the effects of pesticides and fertilizers.[1]	10 years @ $50,000/year	$500,000	2008 - 2018
2. Implement pesticide, fertilizer, and nutrient best management practices to reduce contaminants entering the estuary.	10 years @ $1.15 million/year[2]	$11.5 million	2008 – 2018
3. Evaluate the adequacy of best management practices and update as needed.	2 reviews @ $250,000	$500,000	2012 and 2017

Total costs: $12.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Some users of pesticides and fertilizers are not adequately informed about best management practices for these toxic contaminants. (2) Additional benefits to salmonids could be realized through continued efforts by farmers, chemical manufacturers, and regulatory programs to reduce impacts from fertilizers and pesticides. (3) Benefits to salmonids would increase over a relatively long period of time as agricultural practices improve. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to reduce nutrients and toxic contaminants entering the estuary.

Existing efforts: Both Washington and Oregon produce and encourage implementation of best management practices (BMP) manuals to address non-point sources of pollution. In both states, load allocations and reduction strategies are identified through the total maximum daily load (TMDL) process. The Oregon Department of Environmental Quality is now conducting “pesticide stewardship partnerships” in five Oregon watersheds that eventually flow into the Columbia or Willamette rivers. These partnership programs work through outreach with the agricultural community to implement BMPs that will reduce pesticides in rivers and streams. The U.S. Department of Agriculture, through Senate Bill 1010 authorities, is developing plans to ensure BMPs on agricultural lands. The U.S. Environmental Protection Agency convened the Columbia River Basin Toxics Reduction Working Group in 2005 to coordinate monitoring, cleanup, and reporting efforts basinwide. In September 2010, the working group produced the Columbia River Basin Toxics Reduction Action Plan.

Potential implementers:

- Washington Department of Agriculture
- Oregon Department of Agriculture
- Cities
- Conservation districts
- U.S. Environmental Protection Agency
- Washington Department of Ecology
- Oregon Department of Environmental Quality
- Lower Columbia River Estuary Partnership
- Natural Resources Conservation Service

Notes:

[1] Projects CRE-20.1 and CRE 21.1 both call for outreach efforts. Outreach efforts for these two projects will be combined into a single outreach program whose costs will be shared.

[2] Unit cost includes estimates for the estuary and estuary tributaries only; the action recommends similar upstream activities.

Management Action CRE-21:

Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.

Project	Unit	Cost	Schedule
1. Educate the industrial and commercial sectors and the general public on how to reduce the introduction of pollutants into the estuary and its tributaries.[1]	10 years @ $20,000/year	$200,000	2008 - 2028
2. Identify sources, loads, and pathways of pollutants in the estuary.	8 years @ $100,000/year	$800,000	2010 - 2018
3. Provide cost-share incentives for National Pollution Discharge Elimination System (NPDES) permit holders to upgrade effluent above their permit requirements.	10 years @ $1.5 million/year	$15 million	2010 – 2020
4. Study and establish threshold treatment standards for pharmaceuticals and other unregulated substance discharges; update existing NPDES permits to reflect the new standards.	5 years @ $2 million/year	$10 million	2007 – 2012
5. Provide grants and low-cost loans to permit holders required to treat effluent to standards established in Project No. 3.	10 years @ $2 million/year	$20 million	2012 - 2017

Total costs: $46 million

Geographical priority: Reaches D and G and the Lower Willamette reach.

Key assumptions: (1) Non-permitted discharges that currently are occurring would be identified and curtailed. (2) Financial incentives or support would motivate NPDES permit holders to raise their effluent treatment levels above permit requirements. (3) Releases of industrial and commercial pollutants into the estuary would be reduced over time. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to reduce inputs of pollutants.

Existing efforts: In both Oregon and Washington, pollutant load allocations and reduction strategies are identified through the total maximum daily load (TMDL) process. The Oregon Department of Environmental Quality's (DEQ) Water Quality Program is developing a list of key, persistent bioaccumulative toxic contaminants that have a documented effect on human health, wildlife, and aquatic life. The Oregon Legislature has directed DEQ to report on where persistent bioaccumulative toxic contaminants are coming from and options to reduce their discharge. In addition, legislation required Oregon's 52 largest municipal wastewater treatment plants to develop plans by 2011 to reduce priority persistent pollutants through pollution prevention and toxic reduction. Initial monitoring and reduction efforts are to focus on the Willamette River. The U.S. Environmental Protection Agency convened Columbia River Basin Toxics Reduction Working Group in 2005 to coordinate monitoring, cleanup, and reporting efforts basinwide. In September 2010, the working group produced the Columbia River Basin Toxics Reduction Action Plan. The Lower Columbia River Estuary Partnership has created a long-term monitoring strategy that calls for baseline conventional and toxic contaminant data along with data sufficient to assess trends and biological integrity.

Potential implementers:

- U.S. Environmental Protection Agency
- Washington Department of Ecology
- Oregon Department of Environmental Quality
- Cities
- Trade groups such as the Oregon Association of Clean Water Agencies that represent wastewater dischargers

Notes:

[1] Projects CRE-20.1 and CRE-21.1 both call for outreach efforts. Outreach efforts for these two actions will be combined into a single program whose costs are shared.

Management Action CRE-22:

Restore or mitigate contaminated sites.

Project	Unit	Cost	Schedule
1. Develop criteria and a process for evaluating contaminated sites to establish their restoration potential.	1 phase @ $500,000/phase	$500,000	2007 - 2017
2. Develop an integrated multi-state funding strategy to address contamination cleanup in the estuary from non-identifiable upstream sources.	Out-of-Estuary[1]	n/a	2007 - 2012
3. Restore those contaminated sites that will yield the greatest ecological and economic benefits.	20 years @ $3 million/year	$60 million	2007 - 2027

Total costs: $60.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Monitoring will continue to provide vital data needed to understand the toxic contaminant problem and identify potential solutions. (2) Monitoring will identify hot spots of contamination. (3) Contamination sites will be identified for which responsible parties cannot be determined. (4) Additional analysis would identify contamination sites whose restoration would yield significant ecological and economic benefits. (5) Restoration of contaminated sites would benefit salmonids and the ecosystem over time. (6) The action will include improving the condition of habitats that have been impaired by the contaminants, not just removing pollutants. (7) Clean up will be to levels that support survival and recovery in both the short-term and long-term. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to address contamination cleanup.

Existing efforts: The U.S. Environmental Protection Agency regulates cleanup of contaminated sites under Superfund and other programs, which include monitoring of these sites. The U.S. Environmental Protection Agency convened the Columbia River Basin Toxics Reduction Working Group in 2005 to coordinate monitoring, cleanup, and reporting efforts basinwide. In September 2010, the working group produced the Columbia River Basin Toxics Reduction Action Plan. The Lower Columbia River Estuary Partnership has created a long-term monitoring strategy that calls for baseline conventional and toxic contaminant data along with data sufficient to assess trends and biological integrity. The Estuary Partnership, U.S. Geological Survey, and NMFS completed a 3-year study that compiled and analyzed monthly toxic and conventional pollutant data at five sites, primarily for PAHs, PCBs, estrogenic compounds, flame retardants, current-use pesticides, nutrients, and trace elements, Toxics monitoring of juvenile salmon also was conducted at six sites (for PCBs, PAHs, organochlorine pesticides, and flame retardants) (Lower Columbia River Estuary Partnership 2007). In addition, the Estuary Partnership and NMFS developed three models that describe the role that toxics play in a salmon's life history: a conceptual model of the interactions between contaminants and endangered salmonid species, a contaminant transport and uptake model, and an ecological risk model to provide a quantitative measure of the impact of contaminant exposure on salmonid populations in the Columbia River basin (Spromberg and Johnson 2008, Leary et al. 2005, and Leary et al. 2006).

Potential implementers:

- Lower Col. River Est. Partnership
- Col. River Est. Study Taskforce
- Cities
- Conservation districts
- OR Dept. of Env. Quality
- WA State Dept. of Ecology
- Port districts
- U.S. Geological Survey
- Federal regulatory agencies such as the National. Marine Fisheries Service and U.S. Geological Survey

Notes:

[1] Cost is considered to be outside the purview of estuary-specific projects.

Management Action CRE-23:

Implement stormwater best management practices in cities and towns.

Project	Unit	Cost	Schedule
1. Monitor stormwater outputs to measure treatment compliance with existing local and state regulations throughout the basin; develop a network of monitoring sites and establish a data repository that includes data collected by permittees.	10 years @ $200,000/year	$2 million	2007 - 2015
2. Establish a fund source for regulatory agencies and local governments to use when insufficient resources are available to (1) access best available science, (2) develop standards beyond requirements, or (3) adequately enforce regulations.	3 years @ $2 million/year	$6 million	2009 – 2011
3. Evaluate the adequacy of best management practices and update as needed.	3 evaluations @ $500,000	$1.5 million	2010 – 2025
4. Provide incentives for low-impact development practices.	20 years @ $500,000/year	$10 million	2010 - 2030

Total costs: $19.5 million

Geographical priority: Reaches D and G and the Lower Willamette reach.

Key assumptions: (1) Population growth in the Columbia River basin will continue to influence the hydrology and water quality in the estuary. (2) Stormwater practices could be improved by monitoring and enforcing compliance with existing regulations, making best scientific information available, and developing higher standards. (3) The resulting improvements in hydrology and contaminant exposure in the estuary would occur slowly over time. (4) This action is protective in nature; costs are not associated with retrofitting existing stormwater facilities. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to address stormwater-related water quality issues.

Existing efforts: Both the Washington Department of Ecology and Oregon Department of Environmental Quality produce best management practices manuals to address certain non-point sources. Local governments develop and update land use plans that include stormwater practices and that guide future development. The Lower Columbia River Estuary Partnership has worked with three schools on Schoolyard Stormwater Projects and engaged corporate partners to design and construct stormwater facilities.

Potential implementers:

- Cities and counties
- Washington Department of Ecology
- Oregon Department of Environmental Quality
- U.S. Environmental Protection Agency
- Lower Columbia River Estuary Partnership

Notes:
This action is recommended for upstream mainstem and tributaries, but the costs presented here are for activities in the estuary only.

Table 5-7 is a summary of costs for the 23 management actions. The total estimated budget for constrained implementation of the actions as described in Table 5-6 approaches is $528.05 million over 25 years. This number contrasts with the $1.1 billion estimated to help restore salmon in Puget Sound tributaries over a 10-year period. Other major ecosystem restoration efforts across the United States, including San Francisco Bay, Chesapeake Bay, the Everglades, and the Louisiana Coast, are estimated to cost several billion dollars apiece.

TABLE 5-7
Summary of Costs of Management Actions

Number	Action Description	Cost for Constrained Implementation	%*
CRE-01	Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	$38 million	7%
CRE-02	Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	$20 million	4%
CRE-03	Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	$10 million	2%
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	$44.5 million	8%
CRE-05	Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	$8 million	2%
CRE-06	Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	$6 million	1%
CRE-07	Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	$4.5 million	1%
CRE-08	Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	$27.25 million	5%
CRE-09	Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	$68 million	13%
CRE-10	Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	$75 million	14%
CRE-11	Reduce the square footage of over-water structures in the estuary.	$5.8 million	1%
CRE-12	Reduce the effects of vessel wake stranding in the estuary.	$13 million	2%

Number	Action Description	Cost for Constrained Implementation	%*
CRE-13	Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	$13 million	2%
CRE-14	Identify and implement actions to reduce salmonid predation by pinnipeds.	$15 million	3%
CRE-15	Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	$12.5 million	2%
CRE-16	Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	$10 million	2%
CRE-17	Implement projects to reduce double-breasted cormorant habitats and encourage dispersal to other locations.	$10.5 million	2%
CRE-18	Reduce the abundance of shad in the estuary.	$5.5 million	1%
CRE-19	Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	$3 million	1%
CRE-20	Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	$12.5 million	2%
CRE-21	Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	$46 million	9%
CRE-22	Restore or mitigate contaminated sites.	$60.5 million	11%
CRE-23	Implement stormwater best management practices in cities and towns.	$19.5 million	4%
	Total	$528.05 million	

*Column shows the relative percentage of each action to the total cost. Percentages do not add up to 100 percent because of rounding.

Summary

The estuary and plume ecosystems are especially vulnerable to threats because these ecosystems are affected by factors across a wide geographic range—from upstream to the estuary itself, and even well out in the Pacific Ocean. A set of actions has been identified to help reduce threats to salmonids in the estuary and plume. Other recovery venues must also address upstream threats to effectively improve degraded habitats in the estuary. This estuary recovery plan module uses survival improvement targets to help estimate the level of effort required and the costs of that effort.

CHAPTER 6

Research, Monitoring, and Evaluation[1]

Research, monitoring, and evaluation (RME) is a critical element of recovery planning for ESA-listed species (Crawford and Rumsey 2010). RME provides essential information for planners, implementers, and managers of recovery programs on the effectiveness of their programs, whether individual actions are improving the performance[2] of listed salmonids, and how limiting factors and threats are affecting salmonids. This chapter describes RME needed to assess juvenile salmonid performance in the estuary and to evaluate the effectiveness of the 23 management actions described in Chapter 5. It also describes existing monitoring plans, programs, and projects that relate to estuary module RME needs and identifies gaps and potential projects to fill those gaps.

Monitoring plans for ESA-listed Columbia Basin salmonids have been or will be drafted for all domain recovery plans in the basin. These monitoring plans address the most basic question in recovery planning: Is the status of the listed population or ESU improving? Estuary RME will address other key questions, such as whether the performance of juvenile salmonids passing through and using the estuary is improving or worsening, and whether the limiting factors that affect the status of a population or ESU within the estuary are changing. Accordingly, estuary RME will complement monitoring for recovery plans for all domains in the Columbia River basin. Additional questions addressed by estuary RME are as follows:

- Are the actions identified in the estuary recovery plan module being implemented correctly, in sufficient scope, and according to schedule?
- What are the effects of estuary management actions on juvenile salmonids and their habitat?
- Are additional actions needed?
- Are there additional or new threats and limiting factors within the estuary beyond those considered in the estuary recovery plan module?
- How will the monitoring data be managed, analyzed, interpreted, and disseminated?
- How will monitoring data be incorporated into management decisions to best allow an adaptive management approach?

Monitoring for this estuary recovery plan module needs to build on ongoing efforts. In particular, *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary*

[1] Catherine Corbett of the Lower Columbia River Estuary Partnership and Gary Johnson of Pacific Northwest National Laboratories provided the principal input to this chapter.

[2] Salmonid performance refers to life history diversity, foraging success, spatial structure, and growth (Bottom et al. 2005).

Program (ERME) (Johnson et al. 2008) is an appropriate monitoring plan on which to base the estuary recovery plan module RME. The ERME monitoring plan is important because it formed the basis for estuary RME in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (National Marine Fisheries Service 2008a and 2008b), and was carried over into the 2010 FCRPS Supplemental Biological Opinion (National Marine Fisheries Service 2010). In addition, versions of the ERME monitoring plan have been reviewed by the Independent Scientific Review Panel of the Northwest Power and Conservation Council (Independent Scientific Review Panel 2006a and 2006b), along with state and tribal fisheries management agencies. Finally, the ERME monitoring plan was initially developed and refined by an inter-agency estuary/ocean subgroup for Federal RME that included members from the Bonneville Power Administration, the U.S. Army Corps of Engineers, the Lower Columbia River Estuary Partnership, NMFS, and the Pacific Northwest National Laboratory. This chapter borrows greatly from the Johnson et al. (2008) ERME plan.

In addition to the *Research, Monitoring, and Evaluation Program for the Federal Columbia River Estuary* (Johnson et al. 2008), nine other monitoring plans and guidance documents are applicable to a framework for estuary recovery plan module RME (see Table 6-1). The earliest planning document for estuary RME—*Lower Columbia River Estuary Plan, Aquatic Ecosystem Monitoring Strategy for the Lower Columbia River and Information Management Strategy* (Lower Columbia River Estuary Partnership 1998)—outlined a general monitoring strategy that addressed coordination and oversight, data management and quality assurance, conventional and toxic contaminants, habitat, exotic species, and primary production. This document continues to be germane today. More recently, NMFS produced a document for recovery plans called *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed under the Federal Endangered Species Act* (Crawford and Rumsey 2010). This chapter is consistent with the guidance provided in that document, especially regarding the monitoring framework and adaptive management approach.

RME Framework

The main elements of estuary RME are status and trends monitoring, action effectiveness research, critical uncertainties research, and implementation and compliance monitoring. These elements inform an adaptive management approach that includes synthesis, reporting, and evaluation of monitoring data and use of results to modify management actions and monitoring programs. The main elements of the estuary RME are described below.

Status and Trends Monitoring

The overall objective of status and trends monitoring in the estuary is to determine the status of ESA-listed salmonids, determine environmental conditions that are ecologically significant to listed species, and track how the status changes over time. The results of status and trends monitoring should provide information on ambient environmental conditions and insight into the cumulative effects of existing and new management actions and anthropogenic impacts as they occur.

TABLE 6-1
Monitoring Plans Applicable to Estuary RME

Title	Lead Agency(s)	Description	Application
Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed under the Federal Endangered Species Act (Crawford and Rumsey 2010)	NMFS	This document provides general guidance for monitoring and evaluation within an adaptive management framework for recovery plans for ESA-listed salmonids in the Pacific Northwest.	Estuary recovery plan module RME used the monitoring elements and adaptive management approach espoused in this work.
Lower Columbia River Estuary Plan, Volume 2: Aquatic Ecosystem Monitoring Strategy (Lower Columbia River Estuary Partnership 1998)	Estuary Partnership	The *Monitoring Strategy* makes specific recommendations for monitoring oversight, data management, and monitoring and research on pollutants, toxics, habitat, exotic species, and primary production.	Many of the recommendations in this strategy pertain to the management actions in the estuary recovery plan module and, thus, were inherently applied to module RME.
Columbia River Basin Research Plan (Northwest Power and Conservation Council 2006a)	NPCC	This plan identifies key uncertainties that, if resolved, would support actions to conserve and recover fish and wildlife populations addressed in the BPA/NPCC's Fish and Wildlife Program. There are three uncertainties listed for the estuary, one of the plan's focal areas.	Research called for in this plan informs many of the management actions in the estuary recovery plan module.
Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program (Johnson et al. 2008)	BPA/ NMFS/ NPCC/USACE	This plan for RME in the tidally influenced area, from Bonneville Dam to the ocean, including the plume, has specific goals and objectives, a conceptual ecosystem model, monitored indicators, method and protocols, and an action plan. This is a working document that is periodically updated based on new knowledge and program maturation.	Estuary recovery plan module RME relied on applicable content in this plan.
Guidance for Developing Monitoring and Evaluation as a Program Element of the Fish and Wildlife Program (Northwest Power and Conservation Council 2006b)	NPCC	This report concerns monitoring and evaluation for the Fish and Wildlife Program. It develops monitoring and evaluation guidance at two levels: Council policy-makers and project implementers. The Council's Fish and Wildlife Program was last approved in 2009.	The guidance in this report, although general, is basic to monitoring and evaluation planning and was applied as appropriate in estuary recovery plan module RME.
Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (Lower Columbia Fish Recovery Board 2010)	LCFRB	The plan includes an extensive section on monitoring and research designed to evaluate biological status of listed salmon and steelhead, tributary habitat status, implementation compliance, and action effectiveness.	Applicability to estuary recovery plan module RME is limited because the material focuses on tributary watersheds of the lower Col. R. and estuary.
Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010)	ODFW	This plan includes an extensive section on monitoring and research designed to evaluate biological status of listed salmon and steelhead, status of tributary habitat and other limiting factors, implementation compliance, and action effectiveness.	Applicability to estuary recovery plan module RME is limited because the material focuses on tributary watersheds of the lower Col. R. and estuary
FCRPS 2008 Biological Opinion and 2010 Supplemental Biological Opinion (NMFS 2008 and NMFS 2010)	NMFS	The Reasonable and Prudent Alternative in the 2008 BiOp includes estuary RME actions and subactions. These were incorporated by reference into the 2010 Supplemental BiOp.	There is some overlap between the management actions in the estuary recovery plan module and the RPAs in the Biological Opinions. As appropriate, RME from the Biological Opinions was incorporated into estuary recovery plan module RME.

Title	Lead Agency(s)	Description	Application
Supplement to the Mainstem Lower Columbia River and Estuary Subbasin Plan (Lower Columbia River Estuary Partnership 2004b)	Estuary Partnership	This supplement clarifies and provides additional details about the key elements in the subbasin plan for the estuary. It does not, however, explicitly develop an RME plan.	The supplement supports estuary RME, although specific recommendations are not provided.
Upper Columbia Monitoring and Evaluation Plan (Upper Columbia Technical Recovery Team 2007)	Upper Columbia Technical Recovery Team	This working draft provides a comprehensive plan for tributary RME. Many of the monitoring concepts are consistent with those used in the estuary.	Estuary recovery plan module RME used the monitoring guidance categories in this plan.

The U.S. Environmental Protection Agency (2000) developed 15 guidelines for developing environmental indicators that provide this type of information, including the following:

- Relevance to the assessment. Monitored indicators should be responsive to an identified question and provide information useful for management decisions.
- Linkage to management action. An indicator is useful only if it can provide adequate information to support management decisions or quantify the success of past decisions.
- Temporal variability across years. Although an indicator may show inter-annual variability, the indicator should reflect true trends in environmental conditions for the assessment question. To determine variability across years, monitoring must proceed for several years at relatively stable sites. Having a long time series of data is particularly important in the estuary, where the benefits of habitat restoration could be masked by salmonid population changes that are due to variable ocean conditions.

Examples of indicators include direct measurements (such as nutrient concentrations), indices, and multimetrics (fish assemblage, for example) (U.S. Environmental Protection Agency 2000).

There are two major objectives for status and trends monitoring in the estuary: (1) assess habitat conditions and limiting factors and threats as described in the estuary recovery plan module and (2) assess juvenile salmonid performance in the estuary. Johnson et al. (2008) list the following status and trends objectives for the estuary:

1. Status and Trends Monitoring (STM): Habitat Conditions – Determine the status and trends of monitored indicators for estuary/ocean conditions that are ecologically significant to listed salmonids in the lower river, estuary, plume, and nearshore ocean.

    STM 1. Map bathymetry and topography of the estuary as needed for RME.

STM 2. Establish a hierarchical habitat classification system based on hydrogeomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.

STM 3. Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.

STM 4. Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, substrate characteristics, dissolved oxygen, temperature, conductivity, and primary and secondary production at representative locations in the estuary and plume.

2. Status and Trends Monitoring: Juvenile Salmonid Performance – Determine the status and trends of monitored indicators for juvenile salmonid performance in the estuary and plume.

   STM 5. Evaluate migration characteristics, including juvenile salmonid abundance, residence times, growth rates, diets, and prey resources at representative locations in the estuary and plume to understand habitat usage and relative ecological importance of various habitats to juvenile salmonids.

   STM 6. Monitor and evaluate juvenile salmonid survival from Bonneville Dam through the estuary into the plume.

   STM 7. Develop an index and monitor and evaluate life history diversity of juvenile salmonid populations at representative locations in the estuary.

   STM 8. Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.

Johnson et al. (2008) also provide guidance on potential indicators that can be monitored to provide information relevant to these objectives. Additional information about status and trends monitoring objectives can be found in the *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008).

Action Effectiveness Research

The overall objective of action effectiveness research in the estuary is to provide information about the effects of management actions. Using a representative set of management actions, such as specific types of habitat restoration, researchers monitor a suite of variables to evaluate the effects of individual actions on juvenile salmon and their estuarine habitats and provide feedback on potential methods for improving techniques, locations, or other aspects of the action. Action effectiveness research usually involves project-scale monitoring of site-specific conditions to determine whether implemented actions were effective in creating the desired change and whether project- or program-specific performance goals were met. This type of monitoring also can include long-term post-project implementation monitoring to see whether the actions continue to function as they were designed or intended. In some cases the information needed for action effectiveness monitoring may be provided by status and trends monitoring, but action effectiveness research generally requires focused evaluations of more specific parameters directly associated with actions.

The intent of action effectiveness research (AER) is to use quantitative studies to demonstrate how habitat restoration actions affect factors controlling ecosystem structures and processes at site and landscape scales and produce changes in juvenile salmonid performance. The following sub-objectives are from Johnson et al. (2008):

Using a representative set of projects, monitor and evaluate the effects of habitat restoration actions in the estuary, as follows:

> AER 1. Develop a limited number of reference sites for typical habitats, e.g., tidal swamp, marsh, island, and tributary delta, to use in action effectiveness evaluations.
>
> AER 2. Evaluate the effects of selected individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives. ("Effectiveness Monitoring")
>
> AER 3. Develop and implement a methodology to estimate the cumulative effects of habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem controlling factors, structures, and processes affecting salmon habitats and performance. ("Validation Monitoring")

Critical Uncertainties Research

The overall objective of critical uncertainties research in the estuary is to investigate uncertainties in the state-of-the-science that are pivotal to understanding fish performance within the estuary. Uncertainties include cause-and-effect relationships among fish, limiting factors, threats, and activities meant to protect or enhance fish performance. The following three critical uncertainties were identified as particularly relevant to this module:

- Extent of density dependence mortality in the estuary and the role of large releases of hatchery fish in density dependence
- Effects of climate cycles and global warming on salmonid performance in the estuary
- The amount of increased juvenile survival in the estuary that could reasonably be expected if all 23 management actions in the module were implemented, and the proportion of that increased survival that could be attributed to each action

Critical uncertainties were also identified in Johnson et al. (2008). The following sub-objectives pertain to critical uncertainties research (CUR):

> CUR 1. Continue work to define the ecological importance of the tidal freshwater, estuary, plume and nearshore ocean environments to the viability and recovery of listed salmonid populations in the Columbia Basin.
>
> CUR 2. Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.
>
> CUR 3. Investigate the importance of the early life history of salmon populations in tidal freshwater of the lower Columbia River.

CUR 4. Investigate the effects of hatchery fish on wild (naturally produced) fish in the estuary.

CUR 5. Understand the wetting and drying of the floodplain habitats caused by complex hydrodynamic interactions of tides, mainstem and tributary flows, and the effect of the FCRPS on river conditions.

By testing assumptions related to these and other critical uncertainties, recovery program planners, implementers, and managers can refine the foundation, implementation, and effectiveness of the management actions described in Chapter 5 to incorporate the best available science as it becomes accessible.

Implementation and Compliance Monitoring

The overall objective of implementation and compliance monitoring is to determine whether projects that address management actions are being implemented correctly, in sufficient quantities, and according to schedule. This monitoring is important for evaluating whether recovery programs are meeting objectives and performance measures, such as the number of estuary habitat acres conserved or restored annually. Objectives and performance measures for implementation and compliance monitoring are specific to the programs they evaluate; thus, in this case, performance measures and the resulting implementation monitoring would need to reflect targets derived from the 23 management actions in Chapter 5. Johnson et al. (2008) identified the following implementation and compliance monitoring (ICM) objectives:

ICM 1. Determine whether restoration projects were carried out as planned, i.e., whether specified project criteria were met ("Implementation Monitoring").

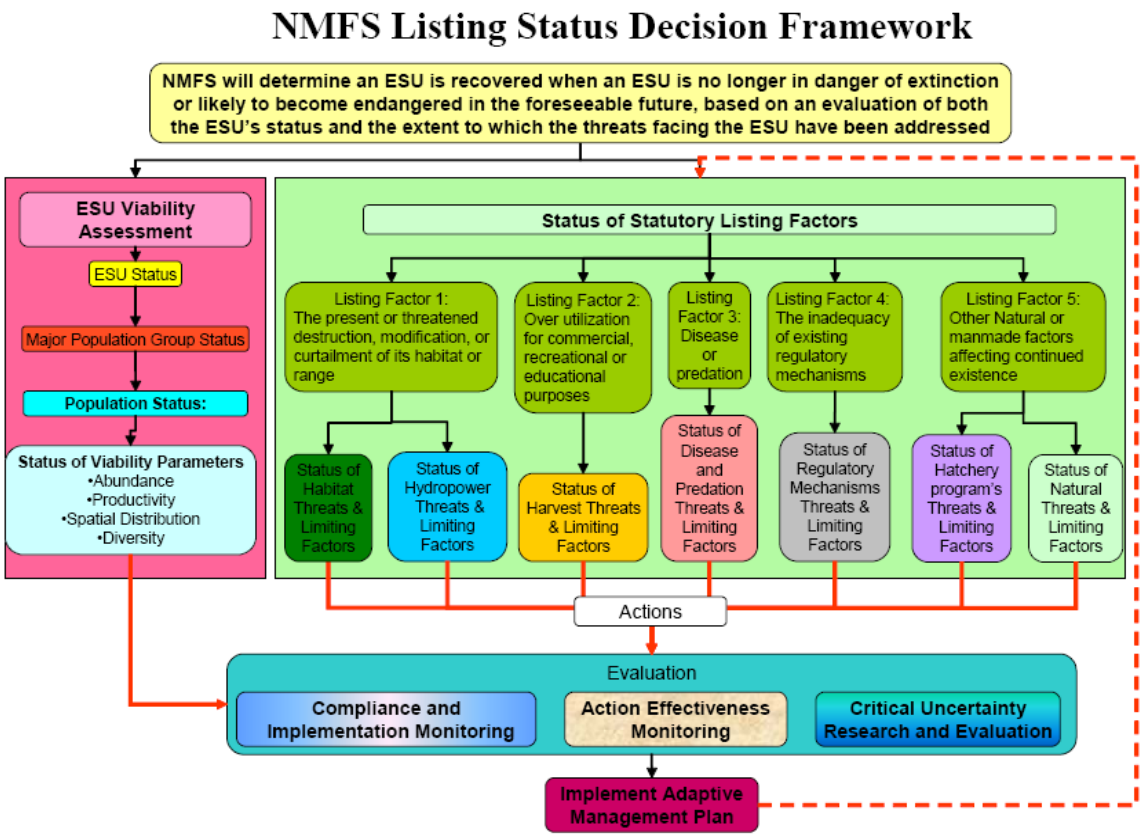
ICM 2. Total the amount of estuary habitat conserved and restored annually by habitat type.

Adaptive Management Approach

Estuary recovery plan module RME will employ an adaptive management approach. Adaptive management is the process of adjusting management actions based on new information. Management actions must be taken in an adaptive, experimental manner because ecosystems are inherently variable and highly complex (Independent Scientific Review Panel 2007). The process works by coupling decision making with the collection and evaluation of performance data and offering an explicit process through which alternative strategies to achieve the same ends can be proposed, prioritized, and implemented when necessary (Crawford and Rumsey 2010).

Figure 6-1 shows the role of RME and adaptive management in NMFS decisions regarding listing salmonids under the Endangered Species Act. The estuary recovery plan module addresses limiting factors and threats, which led to the management actions listed in Chapter 5. The RME described in this chapter will result in new information for use in evaluating the status of statutory listing factors and limiting factors and adjusting management actions as needed.

FIGURE 6-1
NMFS Listing Status Decision Framework (Crawford and Rumsey 2010)



The adaptive management approach in the estuary recovery plan module is intended to achieve effective management actions in the Columbia River estuary ecosystem. For the estuary recovery plan module, adaptive management entails the following:

- Management actions
- Research, monitoring, and evaluation actions
- Coordination and implementation
- Data and information management
- Synthesis, reporting, and evaluation
- Decisions

Estuary-scale adaptive management will benefit from adaptive management planning by individual organizations (such as the Lower Columbia River Estuary Partnership and the U.S. Army Corps of Engineers) for their habitat restoration projects and programs (see Thom et al. 2007).

Coordination

Coordination is critical in implementing RME for the Columbia River estuary, where multiple entities collect data for numerous individual projects with various objectives and potentially different monitoring protocols. Successful implementation and

evaluation of estuary recovery plan module RME will require that ongoing and future RME efforts be coordinated and carried out within an adaptive management framework. An estuary RME information-sharing forum should be established that includes technical representatives of Federal, state, and local government agencies; the Lower Columbia River Estuary Partnership; and other entities involved in research, monitoring, and implementation of recovery actions. This forum would be a valuable mechanism for fulfilling the coordination need and would complement corresponding groups of policy representatives responsible for implementation.

Data and Information Management

Data and other information pertinent to estuary RME are collected by many parties for a wide variety of applications. Data analysis and management are performed at a project and sometimes agency level, but not often at the estuary-wide level. It is neither desirable nor feasible to centrally manage or analyze all data within the Columbia River estuary. However, data should be managed so that synthesis and evaluation occurs through a coordinated, communal information network that includes the following elements:[3]

- Incorporation of data produced by existing programs and information systems to avoid duplication of effort.
- Integration with other basinwide and regional RME groups, including the Pacific Northwest Aquatic Monitoring Partnership.
- Regular written project-level reporting by RME partners within a coordinated system for peer review of project plans and reports.
- Periodic estuary RME workshops to present new data, discuss findings, and exchange information on future plans.
- A system for tracking implementation of RME projects throughout the estuary.
- Establishment of a central, Web-accessible repository and library for estuary data and references.
- Guidelines for metadata standards to facilitate data exchange and application.
- Centrally facilitated program-level review for comprehensive synthesis and evaluation of pertinent information relative to the goals and objectives of this plan.
- Periodic program-level summary reports.
- Communication and information exchange with other West Coast estuary and adaptive management programs, such as the Puget Sound Partnership.
- Consistent participation and funding commitments by partners.

A data management program for the estuary should build on existing efforts, such as the Lower Columbia River Estuary Partnership's monitoring and data management activities. The Estuary Partnership's science work group (and board of directors)

[3] Adapted from Johnson et al. (2008) and Lower Columbia River Estuary Partnership (2004a).

includes technical representatives of Federal, state, and local government agencies and other entities involved in restoration, monitoring, and implementation of recovery programs. This work group complements corresponding groups of policy representatives.

Synthesis, Reporting, and Evaluation

The information from status and trends monitoring, action effectiveness research, critical uncertainties research, and implementation and compliance monitoring should be synthesized and integrated in periodic reports for decision makers and other interested parties. The intent is to "roll up" project-specific data into program-level information. Annual reporting at the project level should be a key mechanism for data dissemination; biennial reporting at the program level should be key to disseminating results of evaluations. The estuary RME information-sharing forum described above could guide the synthesis and roll-up in the biennial report. In an adaptive management process, program evaluation includes adjusting program objectives and methodologies based on new information. As Noon (2003) stated, monitoring programs "must be constantly revisited and revised as scientific knowledge is acquired." Procedures should be established that link decision makers to estuary RME monitoring overseers and data managers. To conclude, Johnson et al. (2008) recommended the following synthesis and evaluation activities:

> SE 1. Upload, compile, manage, and disseminate project-level data at the Estuary Program level.
>
> SE 2. Synthesize the data and periodically report it to the region.
>
> SE 3. Use the synthesized data to evaluate the Estuary Program and refine the estuary RME effort as necessary.

Existing Programs and Projects and Additional Monitoring Needs

Activities conducted as part of the ERME program (Johnson et al. 2008) and other efforts do not fully address all of the monitoring needs associated with the 23 management actions identified in the module. The following sections describe (1) existing monitoring programs and projects and their applicability to the 23 management actions identified in the module; (2) gaps between existing monitoring efforts and needed monitoring for the management actions; (3) additional monitoring activities to fill those gaps and ensure monitoring to support all of the 23 management actions; (4) recommended indicators and protocols; and (5) estimated costs of estuary module RME.

Existing Programs and Projects

Estuary recovery plan module RME will take advantage of ongoing monitoring programs and the projects implemented within them wherever possible to avoid duplication of effort. At least 21 ongoing programs include projects that address aspects of research and monitoring in the estuary (see Table 6-2). The largest RME programs are the Columbia Basin Fish and Wildlife Program, which is funded by Bonneville Power Administration via the Northwest Power and Conservation Council, and the

Anadromous Fish Evaluation Program, which is funded by the U.S. Army Corps of Engineers. These two programs address estuary RME explicitly. The other programs exist for purposes other than estuary RME, but are applicable in a limited fashion.

The research and monitoring effort in the estuary includes at least 42 projects (see Table 6-3). This project list was derived from data in Johnson et al. (2008), the Estuary Partnership's RME inventory (conducted by K. Jones), and the Pacific Northwest Aquatic Monitoring Partnership's RME Project Inventory (database provided by M. Banach, Pacific States Marine Fisheries Commission). The projects include status and trends monitoring, action effectiveness research, and critical uncertainties research.

RME Needs, Existing Project Coverage, and Recommended Projects

Table 6-4 identifies monitoring needs for each of the 23 management actions in the estuary recovery plan module (see Tables 5-2 and 5-6), lists existing projects and programs that help address the needs, and identifies gaps. Table 6-5 identifies potential new projects to fill the RME gaps identified in Table 6-4. In addition, all of the management actions will require implementation and compliance monitoring.

Monitoring Recommendations

Table 6-6 provides recommendations specific to each need identified in Table 6-4. Recommendations include sampling design, spatial and temporal scale, measured variables, measurement protocols, derived variables, analysis, possible funding entities, and potential entities for implementation and coordination. Many of the measured variables and measurement protocols were obtained from Johnson et al. (2008). Specific monitoring methods will developed on a project basis. Habitat restoration monitoring protocols for the Columbia River estuary have been developed and disseminated in Roegner et al. (2009) (Table 6-3, Project J15). Mention of possible funding entities in Table 6-6 does not imply a funding commitment of any kind.

Estimated Costs

Table 6-7 presents estimates of costs and implementation schedules for estuary recovery plan module RME. These cost estimates were developed by Gary Johnson of Pacific Northwest National Laboratories, Catherine Corbett of the Lower Columbia River Estuary Partnership, and Phil Trask of PC Trask & Associates, Inc., by researching existing programs and estimates. The costs identified in this section do not represent a detailed economic analysis; in fact, they are not economic costs, in that they have not been discounted across time. Instead, the cost estimates are in constant dollars over a 25-year period. As mentioned previously, some module actions included specific RME projects and associated cost estimates (see Table 5-6). In those cases, Table 5-6 is referenced. Other costs in Table 6-7 ($64.1 million) were estimated by evaluating the monitoring needs in Table 6-6. The total cost of the RME projects identified in the estuary recovery plan module is $85.1 million.

Summary

Monitoring, research, and evaluation elements identified in *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed under the Federal Endangered*

Species Act (Crawford and Rumsey 2010) and *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008) provide a consistent methodology that supports the RME detailed in this chapter for the estuary recovery plan module. As management actions identified in the module are implemented, it will be important that monitoring and research data are returned to the managers of the recovery effort to determine whether the management actions in the estuary recovery plan module are achieving the desired results.

TABLE 6-2
Ongoing Monitoring Programs Applicable to Estuary RME (as of July 2009). *The program "ID" number was invented for the purpose of this module to provide linkages to Table 6-3.*

ID	Program	Lead Entity	Description	More Information
P1	National Stream Quality Accounting Network (reported in National Streamflow Information Program)	USGS (and OHSU)	Monitoring at Beaver Terminal (RM54); includes water quality and discharge measurements. Water quality components enhanced by OHSU collaboration since summer 2009.	NASQAN: http://water.usgs.gov/nasqan/ Water quality (as of summer 2009): http://columbia.loboviz.com/loboviz/ Columbia River Factsheet: http://water.usgs.gov/ nasqan/progdocs/factsheets/ clmbfact/clmbfact.html
P2	National Water-Quality Assessment Program	USGS	Routine water quality monitoring nationwide; it includes the Willamette basin, but not the estuary.	NAWQA: http://water.usgs. gov/nawqa/ Willamette page: http://or.water.usgs.gov/ projs_dir/pn366/ nawqa.html
P3	Columbia Basin Fish and Wildlife Program	BPA/ NPCC	Contains a measure addressing the question, "Is the Columbia River estuary improving or deteriorating relative to desired conditions?" BPA/NPCC implements estuary RME projects here.	http://www. nwcouncil.org/ library/2000/
P4	Columbia River Channel Improvements Project	USACE	Monitoring occurs as required for ESA concerns.	https://www.nwp. usace.army.mil/ issues/crcip/
P5	Mouth of the Columbia River Project	USACE/ Ports	Monitoring occurs as required for ESA concerns.	https://www.nwp. usace.army.mil/op/n/ projects/
P6	Anadromous Fish Evaluation Program (AFEP)	USACE	Implements the Columbia River Fish Mitigation Project designed to improve survival through the hydrosystem. The USACE does estuary research in AFEP.	https://www.nwd. usace.army.mil/ps/
P7	NOAA General Funds Program	NOAA	Provides funds for specific estuary/ocean research projects by NOAA.	Unknown
P8	Oregon Dept. of Environmental Quality/106/General Funds	ODEQ	Focus is on Willamette, including its confluence with the Columbia River.	http://www.deq.state. or.us/lab/ wqm/watershed.htm
P9	Total Dissolved Gas Monitoring Program	USACE/ USGS	Routine monitoring.	USGS: http://or.water.usgs.gov/ projs_dir/pn307.tdg/ USACE: http:// 137.161.202.92/TMT/ WQ/2001/ MonitorPlan/ tdgmgt01.pdf
P10	Washington Dept. of Ecology Ambient Monitoring Program	WDE	Usually includes at least one mainstem site, in addition to tributary water quality monitoring.	Monitoring Home: http://www.ecy.wa.gov/ programs/eap/ fw_riv/rv_main.html

ID	Program	Lead Entity	Description	More Information
P11	Water Resources Development Act – Ecosystem Restoration Programs	USACE	USACE conducts monitoring of specific restoration actions conducted under these authorities; monitoring maximum cost is 3% total project cost.	https://www.nwp. usace.army.mil/pm/lcr/
P12	Lower Columbia River Ecosystem Restoration General Investigations Feasibility Study (GI Study)	USACE	The purpose of the GI Study is to "investigate and recommend appropriate solutions to accomplish ecosystem restoration in the lower Columbia River and estuary, including wetland/riparian habitat restoration, stream and fisheries improvement, water quality, and water-related infrastructure improvements."	https://www.nwp.usace.army.mil/ pm/cr/envres.asp
P13	Portland Harbor Superfund Assessment Program	EPA	Implements cleanup at the Superfund site in Portland harbor.	EPA: http://yosemite.epa.gov/R10/ CLEANUP.NSF/sites/ ptldharbor
P14	Estuary Partnership Ecosystem, Action Effectiveness and Pile Structure Monitoring Programs	Estuary Partnership	Implements an Ecosystem Condition Status and Trends Monitoring Strategy, Restoration Actions Effectiveness Research and Pile Structure Modification action effectiveness research and critical uncertainties. Funding by BPA/NPCC, EPA, NOAA, and others.	http://www.lcrep.org
P15	NOAA Tides and Currents	NOAA	Geodetic monitoring	http://tidesandcurrents.noaa.gov/
P16	Surface Water Data Collection Program	USGS	Water quality monitoring (at Beaver Terminal combined with OHSU as of summer 2009)	http://columbia.loboviz.com/loboviz/
P17	Volunteer Water Quality Monitoring Program	Will. River Keeper	Volunteer water quality monitoring	
P18	Zebra Mussel Monitoring Program	Portland State Univ.	Monitoring of zebra mussels, an invasive species	Contact: Steven Wells
P19	National Fish and Wildlife Foundation, Columbia River Estuarine Coastal Fund	National Fish and Wildlife Foundation (NFWF)	The Columbia River Estuarine Coastal Fund was established in 2004 to receive community service payments ordered by court settlements resulting from violations of Federal pollution laws.	http://www.nfwf.org/
P20	Ship-wake program	Port of Vancouver/NOAA	Spatial analysis of beach susceptibility for stranding of juvenile salmonids by ship wakes	
P21	(Untitled)	City of Portland	Monitoring of project effectiveness, fish and wildlife, water quality, and stormwater within Portland's waterways, including the lower Willamette River. The City is in the process of revising its monitoring approach, modeling the design on EPA's Environmental Monitoring and Assessment Program.	http://www.portlandonline.com/bes/ Kaitlin.Lovell@bes.ci.portland.or.us

TABLE 6-3
Ongoing Projects Addressing Estuary RME (as of July 2009)
The project "ID" number (e.g., J4) was invented for the purpose of this module to provide linkages to Table 6-4. Project numbers (e.g., 2000-012-00) are specific to the respective program. Program numbers (e.g., P3) correspond to the program ID numbers in Table 6-2.

ID	Title	Project No.	Program	Monitoring Entity
J1	ODEQ Ambient Water Quality Monitoring	Unknown	P8	OR Dept. of Env. Quality
J2	WDOE Ambient Water Quality Monitoring	Unknown	P10	WA Dept. of Ecology
J3	USGS Discharge and Water Quality Monitoring	Unknown	P1	USGS
J4	Ives Is. Chum Salmon Monitoring	2000-012-00	P3	USFWS
J5	Lower Columbia River and Estuary Ecosystem Monitoring Project	2003-007-00	P14 + P3	Estuary Partnership/ NOAA/PNNL/UW/USGS
J6	Total Dissolved Gas Monitoring	PNAMP#409	P9	USGS
J7	Avian Predation on Juvenile Salmonids	1997-024-00	P3	OSU
J8	Tenasillahe Is. Monitoring	Unknown	P11	USFWS
J9	Canada-US Shelf Salmon Survival Study	2003-009-00	P3	DFO
J10	Life History, Habitat Connectivity, and Survival Benefits of Restoration	EST-P-09-01	P6	PNNL/UW
J11	Estimation of Salmon Survival Using Miniaturized Acoustic Tags	EST-P-02-01	P6	NMFS/ PNNL
J12	Tidal Fluvial Habitats and Juvenile Salmon – Current and Historical Linkages	EST-P-10-01	P6	NMFS
J13	Sampling PIT Tagged Juvenile Salmonids Migrating in the Estuary	BPS-W-00-11	P6	NMFS
J14	Survival and Growth of Juvenile Salmonids in the Columbia River Plume	1998-014-00	P3	NMFS
J15	Evaluation of Cumulative Ecosystem Response to Restoration	EST-P-02-04	P6	PNNL/ NMFS/ CREST
J16	Action effectiveness research on habitat restoration projects	EST-P-09-02	P6	USFWS
J17	Historic Habitat Opportunities and Food-Web Linkages of Juvenile Salmon	2003-010-00	P3	NMFS/ OHSU/ PSU/ UW
J18	Acoustic Tracking for Survival (POST)	2003-114-00	P3	Kintama
J19	Relationship Among Time of Ocean Entry, Physical, & Biological Characteristics of Estuary/Plume	EST-P-02-03	P6	NMFS
J20	Effectiveness Monitoring at Sites in Young's Bay	Unknown	P19	CREST
J21	Habitat Restoration Program – Habitat GIS, Reference Sites, Restoration Actions Effectiveness Research and Pile Structure Modification Critical Uncertainties	2003-011-00	P14 + P3	Estuary Partnership
J22	Monitoring at Smith and Bybee Lakes	Unknown	Unknown	Ducks Unlimited

ID	Title	Project No.	Program	Monitoring Entity
J23	Ramsey Lake Restoration Project Monitoring	Unknown	14	City of Portland
J24	Impact of American Shad	2007-275-00	P3	USGS
J25	Caspian Tern Management	2006-002-00	P3	OSU
J26	Tidal Freshwater Monitoring of Juvenile Salmonids	2005-001-00	P3	PNNL/ODFW/UW/NMFS
J27	Effects of Total Dissolved Gas on Chum Fry	SPE-P-07-01	P6	PNNL
J28	CORIE	Unknown	P3+	OHSU
J29	Pile Structure Removal and Modification Study	Unknown	P14	Estuary Partnership/BPA/ USACE
J30	Julia Butler Hansen Tide Gate Replacement	Unknown	P11	USFWS
J31	Comparison of Juvenile Salmonid Stranding Before and After Channel Improvements	Unknown	P4	PNNL/UW
J32	Bonneville Sea Lion Exclusion Study	ADS-02-16	P6	USCAE Fisheries Field Unit
J33	Sea Lion Deterrent System	BPA/NPCC	P3	Smith Root
J34	Caspian Tern Management Measures	AVS-P-08-01	P6	OSU
J35	Double-Crested Cormorant Management Measures	AVS-P-08-02	P6	OSU
J36	Impact of Avian Predation on Smolts	AVS-W-03-01	P6	NMFS
J37	Tides and currents	Unknown	P15	NOAA
J38	Northern Pikeminnow Surveys	1990-077-00	P3	ODFW
J39	Effectiveness Monitoring in the Lower Grays R.	PNAMP#529	P3	CREST
J40	Ives Island – Adult Chum Salmon Monitoring	PNAMP#277	P3	ODFW
J41	Volunteer Water Quality Monitoring	PNAMP#575	P17	Willamette River Keeper
J42	Zebra Mussel Monitoring	PNAMP#425	P18	PSU

TABLE 6-4
Management Actions, Associated Monitoring Needs, and Existing Coverage
Existing projects with "J" prefixes refer to projects listed in Table 6-3.

Management Action	Type	Monitoring Need	Existing Projects and Gaps
CRE-1: Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	STM	Periodic mapping and areal measurement of riparian habitats and their condition using aerial photography to inform prioritization efforts	J5 and J21, although the projects do not do this at this time, but eventually could.
CRE-2: Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	STM	Water temperature monitoring in the estuary to establish baseline	J1, J2, J28
	AER	Monitoring during the hydrosystem temperature experiment	At dams, the US Army Corps of Engineers (USACE) monitors water temperature; revive hydrodynamic modeling
	UR	Reservoir heating study and downstream effects	No existing projects.
CRE-3: Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	STM	Continuous monitoring of Col. River discharge at Beaver Terminal in the estuary	J3 USGS National Streamflow Information Program
CRE-4: Adjust the timing, magnitude and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	STM/ AER	Continuous monitoring of Col. River discharge at Beaver Terminal in the estuary and at Bonneville dam Plume turbidity monitoring using remote sensing	J3 USGS National Streamflow Information Program; J36 NOAA Tides and Currents
	UR	Flood, habitat, and constraints study(s)	No existing projects; revive modeling, e.g., Jay and Kukulka 2003
CRE-5: Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	UR	Effects of reservoir sediment entrapment	No existing projects; the USACE measured sediment entrapment previously.
CRE-6: Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	UR	Evaluate the long-term trajectory of beneficial use of shallow- water habitat creation sites	No existing projects; the USACE applies dredged material for beneficial uses when possible
CRE-7: Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	UR	Dredge technique and operations study	No existing projects; the USACE studied crab entrainment previously (Pearson et al. 2006).
CRE-8: Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	STM	Periodic mapping and length and density measurements of pile structures using the Estuary Partnership's estuary GIS system	J29, J21
	AER	Monitor physical and biological effects of pile removal	J29, J21
	UR	Study fundamental physical and biological characteristics to understand where removal or modification would be advantageous	No existing projects.

Management Action	Type	Monitoring Need	Existing Projects and Gaps
CRE-9: Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	STM	Periodic mapping and areal measurement of off-channel habitat types to inform prioritization and monitoring efforts	J5 and J21
CRE-10: Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	STM	Periodic mapping and length measurements of dike structures using the Estuary Partnership's estuary GIS system.	J21 GIS map of dikes and tide gates
	AER	Effectiveness monitoring studies of tidal reconnections	J30 JBH study, J15 Cumulative effects, J20 Young's Bay
	UR	Ecological importance of tidal reconnections	J15 Cumulative effects J17 Habitat linkages
CRE-11: Reduce the square footage of over-water structures in the estuary.	STM	Periodic mapping and areal measurements of over-water structures using the Estuary Partnership's estuary GIS system. Track permits for construction of shoreline structures	J21 GIS map of over-water structures – needs to be expanded to areal extent, not just linear extent
	UR	Study fundamental physical and biological characteristics to understand where removal would be advantageous	No existing projects in the estuary.
CRE-12: Reduce the effects of vessel wake stranding in the estuary.	STM	Total stranding estimate for entire estuary	No existing projects.
	UR	Factors and stranding reduction study	J31 Before/after CRCIP addresses factors
CRE-13: Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	STM	Monitor trends in predator abundance	J38
CRE-14: Identify and implement actions to reduce salmonid predation by pinnipeds.	STM	Pinniped predation monitoring	J32
	AER	Effectiveness of actions. Monitor actions under Section 120 of the Marine Mammal Protection Act	J32, J33 Section 120 monitoring
	UR	Magnitude of pinniped impact in the estuary	J32 (at BON) - expand to include magnitude of impact throughout estuary
CRE-15: Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	STM	Inventory and map invasive plants	No existing projects; revive Sytsma et al. 2004
	AER	Effectiveness monitoring	Wahkiakum. Community Foundation Columbia Estuary Environmental Education Program (LCEEEP) identification and treatment of invasive weeds on Julia Butler Hansen Wildlife Refuge
CRE-16: Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	STM	Tern monitoring	J25, J34 Tern monitoring
	AER	Effectiveness of habitat shift	J25, J34 Tern management
CRE-17: Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	STM	Cormorant monitoring	J35
	AER	Methods to reduce cormorant abundance	J35 Cormorant management

Management Action	Type	Monitoring Need	Existing Projects and Gaps
CRE-18: Reduce the abundance of shad in the estuary.	STM	Monitor passage of adult shad at Bonneville Dam	USACE Fish counting
	AER	Evaluate effectiveness of control methods	No existing projects.
	UR	Assess ecological effects of shad	J24 Shad impact study
CRE-19: Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	STM	Monitor trends in abundance, distribution, and species composition of invertebrate invasives	No existing projects; revive Sytsma et al. 2004
CRE-20: Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	STM	WQ/toxics monitoring downstream of Bonneville Dam	No existing projects.
	AER	Pre- and post-project monitoring	No existing projects.
	UR	Source tracking; fish health; sublethal and lethal thresholds	No existing projects; J5; no existing projects.
CRE-21: Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	STM	WQ/toxics monitoring	No existing projects; minimal WQ in J1, J2, J3, J5
	AER	Pre- and post-project monitoring	No existing projects.
	UR	Source tracking; fish health; sublethal and lethal threshold.	No existing projects; J5; none
CRE-22: Restore or mitigate contaminated sites.	STM	WQ/toxics monitoring	No existing projects; minimal WQ in J1, J2, J5
	AER	Pre- and post-project monitoring	No existing projects.
	UR	Source tracking; fish health; sublethal and lethal thresholds	No existing projects; J5; none
CRE-23: Implement stormwater best management practices in cities and towns.	STM	Stormwater monitoring	No existing projects; limited monitoring with NPDES permit requirements
	AER	Directed stormwater monitoring	No existing projects.
	UR	Source tracking; improve BMPs and regulations	No existing projects.

TABLE 6-5
Recommended New RME Projects or New Objectives in Existing Projects
These projects would fill gaps where "no existing projects" were noted in Table 6-4.

Action	Type	Project
CRE-2	UR	Water temperature monitoring and modeling for a reservoir heating study
CRE-4	UR	Flood, habitat, and constraints study(s) of the effects of "more normative" flows in the estuary
CRE-5	UR	Measurement of sediment entrapment in mainstem Columbia River reservoirs
CRE-6	UR	Demonstration study of beneficial use of dredged material to create shallow-water habitat
CRE-7	UR	Dredging technique and operations to minimize entrainment of juvenile salmonids
CRE-8	UR	Study fundamental physical and biological characteristics to understand where removal would be advantageous
CRE-11	UR	Assessment of impacts and benefits of removing over-water structures
CRE-12	STM	Total, estuary-wide stranding estimates by species of juvenile salmonid
CRE-15	STM	Routine monitoring of percent cover and distribution of invasive plants by species
CRE-18	AER	Effectiveness study of shad control methods
CRE-19	STM	Routine monitoring of percent cover and distribution of invasive aquatic invertebrates by species
CRE-20, 21, 22, 23	STM	Water quality, stormwater, and toxic contaminants monitoring below Bonneville Dam
CRE-20, 21, 22, 23	AER	Pre- and post-project implementation water quality, stormwater and toxic contaminants monitoring below Bonneville Dam
CRE-20, 21, 22, 23	UR	Determine sources, concentrations, timing, types, and pathways of water quality and toxic contaminant pollutants; sublethal and lethal thresholds in fish and food web

TABLE 6-6
Monitoring Guidance for Estuary Recovery Plan Module RME. Adapted from Appendix C, Johnson et al. (2008).

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-1	Periodic mapping and areal measurement of riparian habitats and their condition	Complete census with ground-truthing	Estuary-wide every 5 years	Length of riparian habitat by type of habitat	GIS-linked aerial photography, Landsat imagery and videography (Evans et al. 2006)	Proportions for each riparian habitat type	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership
CRE-2	Water temperature monitoring in the estuary to establish baseline	Stratified random sampling by reach	At representative sites throughout the estuary essentially continuously	Water temperature	Data loggers (Callaway et al. 2001)	Maximum daily/weekly maximum, seasonal averages	Trend analysis	BPA/NPCC, USGS	BPA/NPCC Fish and Wildlife Program
	Hydrosystem temperature experiment	Modeling	Estuary-wide	Water temperature	Hydrodynamic model	Maximum daily/weekly maximum, seasonal averages	Compare/ contrast	BPA/NPCC, EPA, USGS	Ibid.
	Reservoir heating study and downstream effects	Systematic sampling and modeling	At representative sites throughout the estuary essentially continuously	Water temperature	Data loggers (Callaway et al. 2001)	Maximum daily/weekly maximum, seasonal averages	Compare/ contrast	BPA/NPCC	Ibid.
CRE-3	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary	Systematic sampling	Hourly sampling at Beaver Terminal	Stream discharge (cfs)	USGS gauging station	Annual maximum and minimum, seasonal averages	Trend analysis	USGS	USGS program

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-4	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary and at Bonneville Dam	Systematic sampling	Hourly sampling at Beaver Terminal and BON	Stream discharge (cfs)	USGS gauging station	Annual maximum and minimum, seasonal averages	Trend analysis	USGS, USACE	USGS program (See CRE-3); also USACE O&M program for mainstem dams
	Plume turbidity monitoring using remote sensing	Complete census with ground-truthing	Plume-wide every 5 years	Turbidity	GIS-linked aerial photography	Time series of turbidity maps	Trend analysis	BPA/NPCC, NOAA	BPA/NPCC Fish and Wildlife Program (See CRE-2)
	Flood, habitat, and constraints effects study(s)	Modeling effort	Estuary-wide	Inundation	Hydrodynamic model	Cumulative inundation curves	Compare/ contrast	BPA/NPCC, NOAA	USACE's AFEP
CRE-5	Effects of reservoir sediment entrapment	Complete census	All 13 main-stem Snake and Columbia dams every 5 years	Thickness of reservoir sediment	Acoustic bottom typing (multibeam sonar)	Sediment maps	Trend analysis	USACE	USACE's AFEP (See CRE-4)
CRE-6	Evaluation of beneficial use of dredged material – create shallow-water habitat	Before-after-control-impact (BACI)	Site-specific, 1 year before and 5 years after	Vegetation, bathymetry	Roegner et al. 2009, bathymetry	Percent cover, shallow-water habitat	Effectiveness evaluation	USACE	USACE's Sediment Management Program
CRE-7	Dredge technique and operations study	Focused field experiments	TBD	Crab entrainment	Pearson et al. 2006	Entrainment rates	Statistical analysis	USACE	USACE's Sediment Management Program (See CRE-6)
CRE-8	Periodic mapping and length and density measurements of pile structures	Complete census with ground-truthing	Estuary-wide every 5 years	Length of pile structure	GIS-linked videography (Evans et al. 2006)	Length and locations of pile structure	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1)
	Monitor physical and biological effects of pile removal	BACI	Site-specific, 1 year before and 3 years after	Water velocity, fish species composition and abundance	Data loggers (Callaway et al. 2001), fish by Roegner et al. 2009	Annual max and min velocity, fish species composition proportions	Effectiveness evaluation	USACE	Ibid.

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
	Study fundamental physical and biological characteristics to understand where removal would be advantageous	Systematic sampling	Selected sites for all four seasons over 3 years	Ibid.	Ibid.	Ibid.	Ecological characterization	Ibid.	Ibid.
CRE-9	Periodic mapping and areal measurement of off-channel habitat types	Complete census with ground-truthing	Estuary-wide every 5 years	Length of riparian habitat by type of habitat	GIS-linked aerial photography	Amount of off-channel habitat	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8)
CRE-10	Periodic mapping and length measurements of dike structures	Complete census with ground-truthing	Estuary-wide every 5 years	Length of dike/levee structures	GIS-linked aerial photography	Length of dike/levee structures	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9)
	Effectiveness monitoring studies of tidal reconnections	BACI	Site-specific, 1 year before and 5 years after	Hydrology, vegetation, fish	Roegner et al. 2009	Water surface elevation, percent cover, fish species comosition proportions	Statistical comparison	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9), BPA/NPCC Fish and Wildlife Program (See CRE-2, 4), USACE's AFEP (See CRE-4,5)
	Ecological importance of tidal reconnections	BACI	Site-specific, 1 year before and 5 years after	Prey availability, fish diet, fish residence time, fish stock	Roegner et al. 2009	Diet composition charts	Ecological characterization	BPA/NPCC, USACE, NOAA	Ibid.
CRE-11	Periodic mapping and areal measurements of over-water structures	Complete census with ground-truthing	Estuary-wide every 5 years	Length of over-water structures	GIS-linked aerial photography and videography	Length of over-water structures	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10)
	Track construction permits for shoreline structures	Census	Estuary-wide annually	No. and location of shoreline structures	Contact permitting agencies	Map of structures planned or under construction	Trend analysis	USACE	USACE Regulatory Program

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
	Study fundamental physical and biological characteristics	Systematic sampling	Selected sites for all four seasons over 3 years	Water velocity, light, fish species composition and abundance	Data loggers (Callaway et al. 2001), fish by Roegner et al. 2009	Annual max and min velocity and light levels, fish species composition proportions	Ecological characterization	USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10), BPA/NPCC Fish and Wildlife Program (See CRE-2, 4, 10), USACE's AFEP (See CRE-4, 5, 10)
CRE-12	Total stranding estimate for entire estuary	Stratified random sampling by reach	Estuary-wide over all four seasons of 1 year	Number of juvenile salmonids stranded	Direct counts	Extrapolation to total no. stranded; map of stranding densities	Correlation analysis of factors associated with stranding	USACE	USACE's Channel Improvement Project
	Factors and stranding reduction study	BACI	Selected sites	Ibid.	Ibid.	Average no. stranded w/ and w/o the reduction device	Statistical comparison	USACE	Ibid.
CRE-13	Monitor trends in piscivorous predator abundance	Stratified random sampling by reach	Estuary-wide annually	Catch per unit effort	Electrofishing	Predator densities by location	Trend analysis	BPA/NPCC, USACE, NOAA	USACE's AFEP (See CRE-4, 5, 10, 11)
CRE-14	Pinniped predation monitoring	Systematic sampling	At BON during spring and summer	Number of pinnipeds	Observers	Weekly average abundance	Trend analysis	BPA/NPCC, USACE	USACE's AFEP (See CRE-4, 5, 10, 11, 13)
	Effectiveness of actions (monitor actions under Sec. 120)	BACI	Ibid.	Ibid.	Ibid.	Average abundance	Statistical comparison	USACE	Ibid.
	Magnitude of pinniped impact	Stratified random sampling by reach	Estuary-wide annually	Number of pinnipeds; number of salmon and steelhead consumed per predator; sampling rate	Observers, scat analysis	Estimate of the total number of salmon and steelhead consumed	Trend analysis	NOAA	Ibid.

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-15	Inventory and map invasive plants	Stratified random sampling by reach	Estuary-wide every 5 years	Species composition, abundance, distribution	Site surveys (Sytsma et al. 2004)	Percent cover, maps	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10, 11)
	Effectiveness monitoring	BACI	At selected sites over 3 years	Ibid.	Ibid.	Average percent cover	Statistical comparison	Ibid.	Ibid.
CRE-16	Tern monitoring	Systematic sampling	Reach A during April-August annually	Number of birds	Observers	Number of mating pairs, total local population size	Trend analysis	BPA/NPCC, USACE, NOAA, USFWS	USACE's AFEP (See CRE-4, 5, 10, 11, 13, 14)
	Effectiveness of habitat shift	BACI	Reach A during April-August for 3-5 years	Ibid.	Ibid.	Ibid.	Statistical comparison	Ibid.	Ibid.
CRE-17	Double-crested cormorant monitoring	Systematic sampling	Reach A during April-August annually	Number of birds	Observers	Number of mating pairs, total local population size	Trend analysis	BPA/NPCC, USACE, NOAA, USFWS	USACE's AFEP (See CRE-4, 5, 10, 11, 13, 14, 16)
	Methods to reduce cormorant abundance	Site experiments	Reach A over 1-3 years	Ibid.	Ibid.	Ibid.	Compare/ contrast	Ibid.	Ibid.
CRE-18	Monitor passage of adult shad at BON	Census	Continuous monitoring at BON	Number of adult shad	Observers	Total number per year, weekly and monthly averages	Trend analysis	USACE	BPA/NPCC Fish and Wildlife Program (See CRE-2, 4, 10, 11), USACE's AFEP (See CRE-4, 5, 10, 11, 13, 14, 16, 17)
	Evaluate effectiveness of control methods	Site experiments	Selected sites	Ibid.	Seine, sonar	Number of shad by treatment	Statistical comparison	BPA/NPCC, USACE, NOAA	Ibid.
	Assess ecological effects of shad	Systematic sampling	Selected sites for summer over 3 years	Number of shad, diet, distribution, sex ratio	Various	Total population size, fecundity, etc.	Ecological characterization	BPA/NPCC	Ibid.

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-19	Monitor trends in abundance, distribution, and species composition of invasive invertebrates	Stratified random sampling by reach	Estuary-wide every 5 years	Species composition, abundance, distribution	Site surveys (Sytsma et al. 2004)	Density distribution maps	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10, 11, 15)
CRE-20, 21, 22, 23	Water quality and toxics monitoring downstream of BON	Stratified random sampling by reach, directed source and load tracking	Estuary-wide annual	Concentrations and loads of pollutants, contaminants by source and type	Various	Maps of distribution of pollutant concentration loads, pathways, and sources by type	Every 3 years - trend analysis; concentration loads, and yields by tributary and source	EPA, NOAA, USGS, ODEQ, WDOE	Estuary Partnership (See CRE-1, 8, 9, 10, 11, 15, 19)
	Fish health, sublethal and lethal thresholds	Focused experiments	Laboratory	Fish health/ mortality	Ibid.	Dose response curves	Statistical analysis	Ibid.	Ibid.

[1]Monitoring needs are those identified in Table 6-4.

TABLE 6-7
Estimated Cost and Schedule for Monitoring Needs (includes ongoing projects in some cases)

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
CRE-1: Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	Periodic mapping and areal measurement of riparian habitats and their condition using aerial photography to inform prioritization efforts	Every 5 years, base flyover for data acquisition @ $250K and analysis for riparian zones @ $200K	$1M base plus $800K riparian	2007-2022
CRE-2: Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	Water temperature monitoring in the estuary to establish baseline	Continuous monitoring at four sites (Bonneville Dam, Beaver, St. Helens, and Astoria) for 3 years @ $20K per year and one retrospective study of temperature	$60K (new data from Beaver, St. Helens) plus $50K study	2007-2009
	Monitoring during the hydrosystem temperature experiment	Continuous monitoring at four sites (Bonneville Dam, Beaver, St. Helens, and Astoria) for 5 years @ $20K per year	$100K	2010-2014
	Reservoir heating study and downstream effects	see Table 5-6	see Table 5-6	see Table 5-6
CRE-3: Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary	Data collection and dissemination are routine and ongoing.	$0 (already covered)	2007-2035
CRE-4: Adjust the timing, magnitude and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary and at BON dam	See CRE-3	$0 (already covered)	2007-2035
	Plume turbidity monitoring using remote sensing (satellite)	3 years @ $100K/year	$300K	2009-2011
	Flood, habitat, and constriant study(s)	see Table 5-6	see Table 5-6	see Table 5-6
CRE-5: Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	Effects of reservoir sediment entrapment	see Table 5-6	see Table 5-6	see Table 5-6
CRE-6: Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	Evaluate the beneficial use of dredged material – create shallow-water habitat	see Table 5-6	see Table 5-6	see Table 5-6
CRE-7: Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	Dredge technique and operations study	see Table 5-6	see Table 5-6	see Table 5-6

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
CRE-8: Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	Periodic mapping and length and density measurements of pile structures using the Estuary Partnership's estuary GIS system	One assessment every 5 years @ $200K per assessment	$800K	2007-2022
	Monitor physical and biological effects of pile removal	see Table 5-6	see Table 5-6	see Table 5-6
	Study fundamental physical and biological characteristics to understand where removal would be advantageous	One study for 3 years @ $250K/year	$750K	2007-2009
CRE-9: Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	Periodic mapping and areal measurement of off-channel habitat types to inform prioritization and monitoring efforts	See CRE-1 cost for base flyover, plus analysis of off-channel habitats every 5 years @ $200K per assessment	$800K	2007-2022
CRE-10: Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	Periodic mapping and length measurements of dike structures using the Estuary Partnership's estuary GIS system.	See CRE-9; additional analysis @ $50K per assessment every 5 years	$200K	2007-2022
	Effectiveness monitoring studies of tidal reconnections	Two case studies each in Reaches A-E and one study each in Reaches F-H with samplings in Years 0, 1, 4, 7 @ $100K per sampling-year	$5.2M	2007-2035
	Ecological importance of tidal reconnections	Building on the data from the effectiveness monitoring, one study for 5 years @ $400K per year	$2M	2007-2011
CRE-11: Reduce the square footage of over-water structures in the estuary.	Periodic mapping and areal measurements of over-water structures using the Estuary Partnership's estuary GIS system.	Assessments every 5 years @ $250K per assessment	$1M	2007-2022
	Track permits for construction of shoreline structures	Annual compilation and reporting @ $60K per year	$1.5M	2007-2031
	Study fundamental physical and biological characteristics to understand where removal would be advantageous	One study for 3 years @ $250K/year	$750K	2008-2010
CRE-12: Reduce the effects of vessel wake stranding in the estuary.	Total stranding estimate for entire estuary	One study with sampling three seasons per year at eight sites for 2 years @ $1M per yr	$2M	2009-2010

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
	Factors and stranding reduction study	see Table 5-6	see Table 5-6	see Table 5-6
CRE-13: Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	Monitor trends in predator abundance	see Table 5-6	see Table 5-6	see Table 5-6
CRE-14: Identify and implement actions to reduce salmonid predation by pinnipeds.	Pinniped predation monitoring	One study estuary-wide for 5 years @ $250K per year	$2.5M	2008-2012
	Effectiveness of actions. Monitor actions under Sec. 120	Study every 5 years for 20 years @ $200K (see above)	$0 (already covered)	2013-2032
	Magnitude of pinniped impact in estuary	See pinniped predation monitoring above	$0 (already covered)	2008-2012
CRE-15: Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	Inventory and map invasive plants	see Table 5-6	see Table 5-6	see Table 5-6
	Effectiveness monitoring	see Table 5-6	see Table 5-6	see Table 5-6
CRE-16: Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	Tern monitoring	see Table 5-6	see Table 5-6	see Table 5-6
	Effectiveness of habitat shift	see Table 5-6	see Table 5-6	see Table 5-6
CRE-17: Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	Cormorant monitoring	see Table 5-6	see Table 5-6	see Table 5-6
	Methods to reduce cormorant abundance	see Table 5-6	see Table 5-6	see Table 5-6
CRE-18: Reduce the abundance of shad in the estuary.	Monitor passage of adult shad at Bonneville Dam	Data collection and dissemination are routine and ongoing.	$0 (already covered as part of adult fish counts)	2007-2035
	Evaluate effectiveness of control methods	see Table 5-6	see Table 5-6	see Table 5-6
	Assess ecological effects of shad	One study for 3 years @ $300K per year	$900K	2008-2010
CRE-19: Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	Monitor trends in abundance, distribution, and species composition of invasive invertebrates	Recurring study every 3 years for 30 years @ $500K per year	$5M	2008-2037

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
CRE-20: Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	WQ/toxics monitoring downstream of Bonneville Dam	Annual ambient and directed sampling for 25 years @ $1M/year	$25M	2008-2032
	Pre- and post-project monitoring	Twice annual upstream + downstream sites @ $10K per project @ one project per year for 25 years	$250,000	2008-2032
	Source tracking, fish health, sublethal and lethal thresholds	One study for 5 years @ $500K; fish health @ 5-6 sites per year @ $250K for 25 years; one study for eight priority toxics @ $1.5M for 3 years	$8.25M	2008-2032
CRE-21: Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	WQ/toxics monitoring	See CRE-20	See CRE-20	See CRE-20
	Pre- and post-project monitoring	Ibid.	Ibid.	Ibid.
	Source tracking, fish health, sublethal and lethal thresholds	Ibid.	Ibid.	Ibid.
CRE-22: Restore or mitigate contaminated sites.	WQ/toxics monitoring	See CRE-20	See CRE-20	See CRE-20
	Pre- and post-project monitoring	Ibid.	Ibid.	Ibid.
	Source tracking, fish health, sublethal and lethal thresholds	Ibid.	Ibid.	Ibid.
CRE-23: Implement stormwater best management practices in cities and towns.	Stormwater monitoring	see Table 5-6	see Table 5-6	see Table 5-6
	Directed stormwater monitoring	Twice annual @ 5 cities @ $24K per site for 25 years	$3M	2008-2032
	Source tracking, improve BMPs and regulations	1 study for 5 years @ $500K (see CRE-20); 1 study for 3 years @ $1.5M	$2M	2008-2013

CHAPTER 7

Perspectives on Implementation

Substantial investment is being made in the Columbia River basin to recover listed Chinook, coho, steelhead, and chum. How much of this investment should be made in the estuary? How much do the estuary and plume environments contribute to the survival of upstream ESUs, and is recovery of upstream ESUs possible without a healthier estuary ecosystem? If not, what does the information in Chapters 3, 4, and 5 tell us about which management actions to implement in the estuary?

Chapter 7 explores issues related to the selection of management actions to be implemented in the estuary and how those choices will shape future conditions for salmonids in the estuary and plume. It also suggests next steps in implementation and identifies implementation challenges.

Putting the Estuary in Context

This recovery plan module reflects current scientific understanding that the Columbia River estuary and plume provide habitat that wild salmonids need to complete their life cycles. Historically, juveniles from hundreds of distinct salmonid populations, at various life history stages, used the estuary for refuge and rearing as they prepared physiologically for life in the ocean. Over evolutionary time populations developed life history strategies in which juveniles from different populations staggered their use of the estuary throughout the year, exploiting estuarine habitats in different ways for different lengths of time. Although the estuary posed risks to juvenile salmonids, the diversity in life history strategies allowed salmon and steelhead to take maximum advantage of estuarine resources, which offered tremendous opportunities for refuge and growth. Unlike an upstream tributary, through the year the estuary provided habitat for all of the salmonid populations in the Columbia River basin during a critical stage in their life cycles.

Over the last 200 years the ability of the Columbia River estuary to meet the needs of salmon and steelhead has been seriously compromised. There is no question about the extent of changes in the estuary: the timing, magnitude, and duration of flows do not resemble those of historical flows, access to the estuary floodplain has been virtually eliminated, sediment transport processes that depend on flows and upstream sediment sources are radically different than they were historically, water quality has degraded as a result of contamination, temperatures are approaching and sometimes exceeding lethal limits, and there have been fundamental changes at the base of the estuarine food web, with associated alterations in inter- and intra-species relationships. A central premise of this recovery plan module is that although the estuary ecosystem is degraded, it can be improved, and that a healthier estuary ecosystem would contribute meaningfully to the basinwide recovery of ESA-listed salmonids.

Factors That Influence Decision Making

Decisions about implementation would be easy if protecting and restoring salmonids were the only consideration. However, as much as we value healthy native fish runs, as a society we also value a stable economy, financial opportunity for individuals and businesses, public safety, and property rights. These values will play into decisions about which management actions to implement, as will the three factors used to evaluate the management actions in Chapter 5: cost, constraints, and potential benefits to salmonids.

Also affecting choices about implementation is scientific uncertainty. Although fisheries science has matured over the last 100 years, how salmonids interact in complex ecosystems is not well understood; this is especially true in the estuary and plume. Yet we cannot wait until uncertainty has been eliminated before taking action. In the face of scientific uncertainty, then, decisions about implementing management actions will have to be made using the most current scientific information available, combined with best professional judgment. Historically, it has been a mix of science and policy choices that have guided decisions that affected the estuary; it is likely that these same forces will also determine the effectiveness of science-driven recovery efforts.

Significance of Constraints to Implementation

Not a single management action identified in Table 5-1 will be easy to implement. In one way or another, implementation of each of the 23 actions is constrained, in some cases greatly. Understanding the nature and magnitude of constraints to the implementation of management actions is important for several reasons. First, it grounds the actions in the real world and tempers expectations for results. Second, it provides insights into the level of effort that would be required for an action to have a sizable impact on salmonid populations. Third and most important, it reveals that every proposed action in this recovery plan module has significant obstacles to implementation.

Because it will be difficult to implement any single action fully and gain all of its potential benefit to salmonids, it will be important to implement a relatively large number of the proposed management actions. In other words, if each management action in the estuary has significant constraints, it may take partial implementation of all or most of the actions to improve the health of the estuary ecosystem to the point that the ecosystem provides the benefits that salmonids need to recover.

To illustrate the relative constraints of different actions, Table 7-1 presents management actions by degree of constraint to implementation, in descending order.

Table 7-1
Management Actions Sorted by Degree of Constraint

#	Action	Degree of Constraint
CRE-02	Operate the hydrosystem to reduce reservoir heating.	5
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	5
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	5
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5
CRE-18	Reduce shad abundance.	5
CRE-19	Prevent aquatic invertebrate introductions.	5
CRE-14	Reduce predation by pinnipeds.	4
CRE-15	Reduce invasive plants.	4
CRE-17	Redistribute cormorants.	4
CRE-21	Identify and reduce sources of pollutants.	4
CRE-20	Implement pesticide/fertilizer BMPs.	4
CRE-9	Protect/restore high-quality off-channel habitat	3
CRE-10	Breach, lower, or relocate dikes and levees.	3
CRE-12	Reduce vessel wake stranding.	3
CRE-22	Restore or mitigate contaminated sites.	3
CRE-11	Reduce over-water structures.	3
CRE-01	Protect/restore riparian areas.	3
CRE-06	Use dredged materials beneficially.	3
CRE-16	Redistribute Caspian terns.	2
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	2
CRE-13	Manage pikeminnow and other piscivorous fish.	2
CRE-23	Implement stormwater BMPs.	2
CRE-08	Remove or modify pilings and pile dikes	2

Another useful table when considering implementation constraints is Table 5-3, which shows the differences in potential benefit to salmonids if implementation of actions is unconstrained, versus constrained, which represents a more realistic scenario. However, although Table 5-3 demonstrates the size of the gap between unconstrained and constrained implementation of actions, it does not adequately characterize the magnitude of response that might be expected from constrained implementation. The next section of this document is intended to help show the potential benefit from constrained implementation of actions.

Management Actions Offering the Greatest Survival Benefits

If we were to increase our investment in restoration of the Columbia River estuary by an order of magnitude, what would the ecological return on that investment be? Our ability to answer that question is limited by a lack of understanding of how much mortality actually occurs in the estuary and plume. Still, we do have some information about potential gains that reasonably could be expected as a result of such investment.

Juvenile Survival Improvement. In Chapter 5, survival improvement targets were developed as a tool for comparing the potential benefits of implementing different management actions. This planning exercise used the best available information about estuary mortality for wild, ESA-listed stream- and ocean-type juveniles and then established a 20 percent survival improvement target for the 22 management actions that would affect the survival of juveniles. The survival improvement targets were then allocated across the various management actions to help characterize where survival gains might occur. The results are not intended to represent a deterministically based analysis; however, they do reflect information in the scientific literature, especially about mortality resulting from terns, cormorants, ship wake stranding, contaminants, and pinnipeds.

Tables 7-2 and 7-3 summarize the results of this planning exercise, sorting actions by their potential to improve survival of stream- and ocean-type juveniles, respectively, assuming that implementation of the actions is constrained. This ordering is simply an exercise to hypothesize where survival improvements equal to 20 percent of the number of juveniles exiting the estuary and plume might be expected for stream-type and ocean-type juveniles.

For stream-type salmonids, the following observations can be made from Table 7-2:

- Approximately 60 percent of the survival improvements are assigned to the top five actions, which include adjusting flow, protecting or restoring off-channel habitat, restoring or mitigating contaminated sites, and managing birds that prey on salmonids.
- Approximately 30 percent of the survival improvements are assigned to establishing or improving access to off-channel habitat, protecting and restoring riparian areas, reducing sources of pollutants, managing piscivorous fish, and removing or modifying pilings and pile dikes.
- Approximately 10 percent of the survival improvements are assigned across the remaining actions, with varying degrees of improvements.

For ocean-type salmonids, the following observations can be made from Table 7-3:

- Approximately 65 percent of the survival improvements are assigned to the top five actions, which include adjusting flows, establishing or improving access to off-channel habitat, protecting or restoring off-channel habitat, and addressing issues of contamination.
- Approximately 30 percent of the survival improvements are assigned to protecting and restoring riparian areas, reducing reservoir heating, removing or modifying pilings and pile dikes, reducing vessel wake stranding, using dredged materials beneficially,

managing piscivorous fish, and implementing pesticide, fertilizer, and stormwater BMPs.

- Approximately 5 percent of the survival improvements are assigned across the remaining actions, with varying degrees of improvements.

Table 7-2
Management Actions Sorted by Benefit to Stream-type Juveniles

#	Action	Survival Target (Stream Types)	Percentage of Target Improvements
CRE-16	Redistribute Caspian terns.	350,000	~60%
CRE-17	Redistribute cormorants.	250,000	
CRE-09	Protect/restore high-quality off-channel habitat.	150,000	
CRE-22	Restore or mitigate contaminated sites.	142,000	
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	125,000	
CRE-13	Manage pikeminnow and other piscivorous fish.	122,000	~30%
CRE-10	Breach, lower, or relocate dikes and levees.	100,000	
CRE-01	Protect/restore riparian areas.	100,000	
CRE-08	Remove or modify pilings and pile dikes	100,000	
CRE-21	Identify and reduce sources of pollutants.	72,000	
CRE-20	Implement pesticide/fertilizer BMPs.	42,000	~10%
CRE-23	Implement stormwater BMPs.	30,000	
CRE-02	Operate the hydrosystem to reduce reservoir heating.	20,000	
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	20,000	
CRE-06	Use dredged materials beneficially.	15,000	
CRE-15	Reduce invasive plants.	15,000	
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	10,000	
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5,000	
CRE-18	Reduce shad abundance.	5,000	
CRE-11	Reduce over-water structures.	3,000	
CRE-19	Prevent aquatic invertebrate introductions.	2,000	
CRE-12	Reduce vessel wake stranding.	2,000	
	Total:	1.68 million	

TABLE 7-3
Management Actions Sorted by Benefit to Ocean-type Juveniles

#	Action	Survival Target (Ocean Types)	Percentage of Target Improvements
CRE-10	Breach, lower, or relocate dikes and levees.	450,000	~65%
CRE-09	Protect/restore high-quality off-channel habitat.	400,000	
CRE-22	Restore or mitigate contaminated sites.	300,000	
CRE-21	Identify and reduce sources of pollutants.	275,000	
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	225,000	
CRE-01	Protect/restore riparian areas.	150,000	~30%
CRE-08	Remove or modify pilings and pile dikes	150,000	
CRE-13	Manage pikeminnow and other piscivorous fish.	140,000	
CRE-02	Operate the hydrosystem to reduce reservoir heating.	90,000	
CRE-23	Implement stormwater BMPs.	65,000	
CRE-12	Reduce vessel wake stranding.	55,000	
CRE-20	Implement pesticide/fertilizer BMPs.	50,000	
CRE-06	Use dredged materials beneficially	50,000	
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	25,000	~5%
CRE-11	Reduce over-water structures.	25,000	
CRE-15	Reduce invasive plants.	20,000	
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	8,000	
CRE-19	Prevent aquatic invertebrate introductions.	8,000	
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5,000	
CRE-18	Reduce shad abundance.	5,000	
CRE-16	Redistribute Caspian terns.	2,000	
CRE-17	Redistribute cormorants.	2,000	
	Total:	2.5 million	

While many of the actions are highly constrained, the planning exercise summarized in Tables 7-2 and 7-3 assumes that, even with incremental changes associated with constrained implementation, certain actions could yield significant results, especially when coupled with complementary actions. For example, ocean-type juveniles rely heavily on off-channel habitats for food sources and rearing opportunities. The two primary actions intended to improve access to off-channel habitats are CRE-10, "Breach, lower, or relocate dikes and levees," and CRE-4, "Adjust the timing, magnitude, and frequency of hydrosystem flows." Implementation of both of these actions is highly constrained, yet they could have synergistic effects and their joint implementation—even if only partial—could result in significant survival improvements for ocean-type salmonids. In contrast, if only one of these actions were implemented (or, worse yet, neither), other actions would need to be implemented as fully as possible in an attempt to compensate for the foregone opportunity to address one of the main factors limiting juvenile salmonid performance in the estuary.

Adult Survival Improvement. Because CRE-14, "Reduce predation by pinnipeds," is the only action that directly addresses the adult life history stage of salmonids, this action is treated separately and is not included in Tables 7-2 and 7-3. In 2010, which saw the largest spring Chinook and steelhead runs from 2002 to 2010, pinniped predation on spring Chinook and steelhead (both of which are stream types) at Bonneville Dam was estimated to be 2.2 percent. This equates to 6,081 spring Chinook and steelhead out of a run size of 267,194 fish (U.S. Army Corps of Engineers 2010). Projects to reduce pinniped predation have had limited success, and more stringent management techniques are constrained by protections afforded by the Marine Mammal Protection Act. Although the act does provide for lethal control, the process for implementing that provision is challenging. In 2008, NMFS granted authority under Section 120 of the Marine Mammal Protection Act to the states of Oregon, Washington, and Idaho to intentionally take, by lethal methods, individually identifiable California sea lions that prey on Pacific salmon and steelhead at Bonneville Dam, but the effectiveness of this approach is unknown. Given these constraints, PC Trask & Associates, Inc., in consultation with NMFS Northwest Regional Office staff, estimated that CRE-14 might result in a 17 percent reduction in pinniped-related mortality of adults at Bonneville Dam each year (approximately 1,034 fish annually as applied to 2010 run returns).

Costs for Constrained Implementation of Management Actions

As discussed in Chapter 5, estimating the cost of the management actions in this module is inherently difficult and involves significant uncertainties. This is partly because in many cases, the constraints to implementation have not yet been explored in enough detail to be able to determine what is and is not possible, and key scientific and technical questions about the estuary have not yet been answered. In Chapter 5, Table 5-6 established cost estimates for constrained implementation of actions by assuming an optimistic view—that constraints can be reduced through focused effort and that positive changes in the estuary can be made. A more pessimistic view would likely yield a significantly lower cost estimate, with correspondingly smaller survival improvements. Costs were assigned at the project scale to help identify possible components to actions, with the expectation that future refinements would yield a more sophisticated estimate. Finally, project costs were estimated over a 25-year time horizon.

Table 7-4 organizes management actions by total estimated cost (from Table 5-6). The following observations can be made:

- Costs for the top six actions total $332 million, or about 63 percent of the entire budget. The actions include restoring contaminated sites, modifying flows, reducing sources of pollutants, establishing or improving access to off-channel habitats, protecting or restoring off-channel habitats, and protecting and restoring riparian areas.
- Costs for the next six actions on the list equal $108 million, or about 20 percent of the budget. This group of actions consists of reducing reservoir-related temperature changes, implementing stormwater BMPs, addressing vessel wake stranding, removing or modifying pilings and pile dikes, and managing fish and pinnipeds that prey on salmonids.
- The final 11 actions on the list equal $88 million, or about 17 percent of the budget.

TABLE 7-4
Management Actions Sorted by Estimated Cost

#	Action	Cost of Action	Cost per Group of Actions
CRE-10	Breach, lower, or relocate dikes and levees.	$75 million	~$332 million, or 63% of total
CRE-09	Protect/restore high-quality off-channel habitat.	$68 million	
CRE-22	Restore or mitigate contaminated sites.	$60.5 million	
CRE-21	Identify and reduce sources of pollutants.	$46 million	
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	$44.5 million	
CRE-01	Protect/restore riparian areas.	$38 million	
CRE-08	Remove or modify pilings and pile dikes	$27.25 million	~$108 million, or 20% of total
CRE-02	Operate the hydrosystem to reduce reservoir heating.	$20 million	
CRE-23	Implement stormwater BMPs.	$19.5 million	
CRE-14	Reduce predation by pinnipeds.	$15 million	
CRE-13	Manage pikeminnow and other piscivorous fish.	$13 million	
CRE-12	Reduce vessel wake stranding.	$13 million	
CRE-15	Reduce invasive plants.	$12.5 million	~$88 million, or 17% of total
CRE-17	Redistribute cormorants.	$10.5 million	
CRE-20	Implement pesticide/fertilizer BMPs.	$12.5 million	
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	$10 million	
CRE-16	Redistribute Caspian terns.	$10 million	
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	$8 million	
CRE-06	Use dredged materials beneficially.	$6 million	
CRE-11	Reduce over-water structures.	$5.8 million	
CRE-18	Reduce shad abundance.	$5.5 million	
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	$4.5 million	
CRE-19	Prevent aquatic invertebrate introductions.	$3 million	
	Total:	$528.05 million	

As also discussed in Chapter 5, there is significant uncertainty in these cost estimates because of the ambiguity about the degree to which constraints to implementation can be overcome, the level of effort that would be required to achieve a measurable result, and how new information could change current understanding about the cost and effectiveness of management actions. However, it is assumed that if restoring the ecosystem of the Columbia River estuary were established as a goal, this would require financial investment on a par with that for other major ecosystem recovery efforts around the United States.

Cost-Effectiveness of Management Actions

Cost-effectiveness is an important consideration when attempting to achieve large goals with limited resources, and the more limited the resources with respect to the goal, the more important it is that the maximum benefit be obtained from each expenditure. In the case of the Columbia River estuary, improving conditions for salmonids is likely to be an expensive and long-term effort—one that will require careful consideration of the survival benefits and costs of possible actions.

The linkage between the survival benefits and costs in this recovery plan module is difficult to characterize accurately because of the margin of error that, at this point, exists in both the estimated costs and the survival targets. Because the survival improvement targets were allocated across the set of actions as a planning exercise rather than as results of a scientific analysis, it is the allocation that is most important, not the target numbers themselves. In the case of costs, estimates were made assuming that constraints to implementation of actions could be partially overcome; this assumption served as a way to explore the degree of constraints and the level of effort that would be required to bring about significant benefits to salmonids. The resulting costs should be viewed as preliminary numbers useful in starting critical discussions about decisions that will shape the future of the estuary.

Understanding that, as outlined above, there are limitations governing the survival improvement targets and cost estimates, these sets of numbers can be compared to provide clues about which management actions might be the most cost-effective. Table 7-5 makes such a comparison, using cost information from Table 7-4 and target survival improvements from Table 7-3 to estimate the cost-effectiveness of each action, expressed as a cost/survival index. The actions are sorted in ascending order to show the most cost-effective actions first.

Table 7-5 is intended as a general indication of cost-effectiveness to help frame the discussion about implementing management actions. Also, some actions were assigned very conservative survival improvement numbers because of the level of uncertainty about underlying ecological processes. This is the case with several actions related to the food web because the connection between food web changes and effects on juveniles is not fully defined. As a result, the cost-effectiveness ratings of these actions appear high.

TABLE 7-5
Management Actions Sorted by Cost/Survival Index

#	Action	Survival (Ocean Types)	Survival (Stream Types)	Total Survival	Cost of Action	Cost/ Survival Index
CRE-16	Redistribute Caspian terns.	2,000	350,000	352,000	$10 million	28
CRE-17	Redistribute cormorants.	2,000	250,000	252,000	$10.5 million	42
CRE-13	Manage pikeminnow and other piscivorous fish.	140,000	122,000	262,000	$13 million	50
CRE-06	Use dredged materials beneficially.	50,000	15,000	65,000	$6 million	92
CRE-08	Remove or modify pilings and pile dikes	150,000	100,000	250,000	$27.25 million	109
CRE-09	Protect/restore high-quality off-channel habitat.	400,000	150,000	550,000	$68 million	124
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	225,000	125,000	350,000	$44.5 million	127
CRE-21	Identify and reduce sources of pollutants.	275,000	72,000	347,000	$46 million	133
CRE-20	Implement pesticide/fertilizer BMPs.	50,000	42,000	92,000	$12.5 million	136
CRE-10	Breach, lower, or relocate dikes and levees.	450,000	100,000	550,000	$75 million	136
CRE-22	Restore or mitigate contaminated sites.	300,000	142,000	442,000	$60.5 million	137
CRE-01	Protect/restore riparian areas.	150,000	100,000	250,000	$38 million	152
CRE-02	Operate the hydrosystem to reduce reservoir heating.	90,000	20,000	110,000	$20 million	182
CRE-23	Implement stormwater BMPs.	65,000	30,000	95,000	$19.5 million	205
CRE-11	Reduce over-water structures.	25,000	3,000	28,000	$5.8 million	207
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	25,000	20,000	45,000	$10 million	222
CRE-12	Reduce vessel wake stranding.	55,000	2,000	57,000	$13 million	228
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	8,000	10,000	18,000	$4.5 million	250
CRE-19	Prevent aquatic invertebrate introductions.	8,000	2,000	10,000	$3 million	300
CRE-15	Reduce invasive plants.	20,000	15,000	35,000	$12.5 million	357
CRE-18	Reduce shad abundance.	5,000	5,000	10,000	$5.5 million	550
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5,000	5,000	10,000	$8 million	800

The following observations can be made from Table 7-5:

- The median of all assigned cost/survival index numbers is 144. (The median is the middle number of a group of numbers, with half the numbers having values greater than the median and half having values less than the median).
- Some of the actions that appeared most cost-prohibitive in Table 7-4, such as establishing or improving access to off-channel habitat (CRE-10), adjusting flows (CRE-04), and restoring or mitigating contaminated sites (CRE-22), emerge as cost-effective when viewed in the context of the survival improvements they could bring about. All three of these actions have a cost/survival index value that is less than the median and that puts them in the top—or more cost-effective—half of Table 7-5.
- Several actions, including redistributing terns (CRE-16), redistributing cormorants (CRE-17), and managing piscivorous fish such as pikeminnow (CRE-13), appear to be very cost-effective.

In this planning exercise, the total survival improvement of actions listed above the median is 3.5 million juveniles (2.0 million ocean type and 1.5 million stream type), or about 17 percent of the total number of juveniles currently thought to be exiting the estuary.

Improving Ecosystem Health

The Columbia River estuary and plume ecosystems are degraded compared to historical conditions. One hypothesis of this recovery plan module is that if the estuary and plume remain in their degraded state, recovery of all 13 ESUs may not be possible. The remainder of this section is intended to help characterize choices that will ultimately govern the health of the estuarine ecosystem in the Columbia River.

Is there really a problem for salmonids in the estuary? Sources such as *Salmon at River's End* (Bottom et al. 2005), and emerging micro-acoustic tagging studies make clear that the mortality rate in the estuary is very high and almost certainly approaches 50 percent for some ESUs. This alone argues for discarding the old paradigm of the estuary as primarily a transportation corridor for salmonids on their journey to the ocean. Stream- and ocean-type salmonids clearly rely on estuary and plume habitats for crucial rearing and refuge opportunities during one of the stages in their life cycles. Chapters 3 and 4 of this estuary recovery module describe the mechanisms by which a degraded estuarine ecosystem puts juvenile salmonids at risk.

Is ecosystem restoration necessary in the estuary, or can we surgically reduce specific threats to improve salmonid survival? Ecosystem health in the estuary and plume is the cumulative result of many stressors that originate within the estuary and also outside of the estuary. The level of constraint observed in each of the management actions identified in this estuary recovery module is high, and it is extremely unlikely that one or more actions could be implemented to the degree that they would essentially eliminate a threat to salmonids. Thus each management action should be implemented to the greatest degree practical, unless it is proven that to do so would seriously undermine public safety, the economy, or property rights.

What suite of actions is most important to implement for ocean-type salmonids? There is no single correct answer to this question. In the long term, ecosystem restoration will provide the most stable, self-supporting conditions for salmonids and other native species. Ocean-type juvenile salmonids rear longer in the estuary than stream types do and therefore would benefit the most from improved ecosystem health.

The analysis and planning exercises in this recovery plan module suggest that the following actions are most important for ocean-type salmonids:

- CRE-01: Protect/restore riparian areas.
- CRE-02: Operate the hydrosystem to reduce reservoir heating.
- CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.
- CRE-08: Remove or modify pilings and pile dikes.
- CRE-09: Protect/restore high-quality off-channel habitat.
- CRE-10: Breach, lower, or relocate dikes and levees.
- CRE-13: Manage pikeminnow and other piscivorous fish.
- CRE-21: Identify and reduce sources of pollutants.
- CRE-22: Restore or mitigate contaminated sites.

Implementing this suite of actions would cost approximately $392.3 million and would be expected to yield survival improvements of roughly 2.2 million wild, ESA-listed ocean-type juveniles, or 88 percent of the survival target for ocean-type salmonids. In other words, for ocean-type juveniles, 88 percent of the gain to be had from the management actions could be achieved by implementing these nine actions.

What suite of actions is most important to implement for stream-type salmonids? Stream-type salmonids prefer deeper waters with higher velocities than ocean-types do. They also reside in the estuary for shorter periods of time, but they tend to use the plume more extensively than do ocean-type salmonids. Stream-type juveniles are thought to actively feed in the estuary; information indicates that stream types travel out of the channel to forage and may encounter predators such as the northern pikeminnow (Casillas 2006). For stream types, it is very important to reduce Caspian tern and double-crested cormorant predation. In addition, predation by pinnipeds on adult spring Chinook and winter steelhead is a significant threat.

The analysis and planning exercises in this recovery plan module suggest that the following actions are most important for stream-type salmonids:

- CRE-01: Protect/restore riparian areas.
- CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.
- CRE-08: Remove or modify pilings and pile dikes.
- CRE-09: Protect/restore high-quality off-channel habitat.
- CRE-10: Breach, lower, or relocate dikes and levees.
- CRE-13: Manage pikeminnow and other piscivorous fish.
- CRE-14: Reduce predation by pinnipeds.
- CRE-16: Redistribute Caspian terns.
- CRE-17: Redistribute cormorants.
- CRE-21: Identify and reduce sources of pollutants.
- CRE-22: Restore or mitigate contaminated sites.

Implementing this suite of actions would cost approximately $407.8 million and would be expected to yield survival improvements of roughly 5,000 stream-type adults (ESA-listed and non-listed adults) and 1.51 million wild, ESA-listed stream-type juveniles, or 90 percent of the survival target for stream-type juveniles. In other words, for stream-type juveniles, 90 percent of the gain to be had from the management actions could be achieved by implementing these 11 actions.

How cost-effective are the top actions for ocean- and stream-type salmonids? Of the top 11 priority actions for stream- and ocean-type salmonids, nine are listed at or above the median cost/survival index.

What would be gained by implementing actions that benefit both ocean- and stream-type salmonids? The lists of priority actions identified above for ocean- and stream-type salmonids contain eight actions that are predicted to benefit both types of salmonids. These actions are as follows:

- CRE-01: Protect/restore riparian areas.
- CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.
- CRE-08: Remove or modify pilings and pile dikes.
- CRE-09: Protect/restore remaining high-quality off-channel habitat.
- CRE-10: Breach, lower, or relocate dikes and levees.
- CRE-13: Manage pikeminnow and other piscivorous fish.
- CRE-21: Identify and reduce sources of pollutants.
- CRE-22: Restore or mitigate contaminated sites.

Implementing this set of actions would cost approximately $372.25 million and would be expected to yield survival improvements of roughly 3 million wild, ESA-listed juvenile salmonids (ocean- and stream-types combined). Although the majority of these would be ocean types, there is an argument to be made for favoring actions that would benefit both salmonid types—namely, that implementing such actions would be likely to provide benefits across the spectrum of life history strategies that juvenile salmonids of both types employ in the estuary. Many of the actions that benefit stream-type salmonids would also benefit ocean types displaying less dominant life history strategies, while many actions benefiting ocean-type salmonids would also benefit stream types displaying less dominant life history strategies. Actions that benefit both ocean and stream types, then, presumably would affect a wide range of less dominant life history strategies and thus would help preserve the diversity that contributes to salmonids' ability to persist in the face of changing environmental conditions.

However, this is not to suggest implementation only of those actions that would benefit both ocean- and stream-type juveniles because there are limitations to this approach. For instance, avian and pinniped predation actions, which would primarily benefit stream types, are cost-effective and critical to improving the survival of stream-type salmonids.

Will management actions have synergistic effects? Many of the management actions could have far-reaching effects if they were implemented together, either because they address multiple interrelated threats, such as flow regulation and impaired sediment transport, or because their effects could amplify the benefits of other, complementary management actions. An example would be the two actions of improving flows and establishing access to off-channel habitat by breaching dikes or levees. Although each action by itself would

increase salmonid access to off-channel habitat, implementing both actions has the potential to offer exponentially greater access, as well as contribute macrodetrital inputs to the food web and offer other ecosystem benefits. Although such benefits are difficult to quantify, the potential for synergistic effects of complementary actions is real and should be taken into consideration when management actions are selected.

The U.S. Army Corps of Engineers currently is studying the cumulative effects of various combinations of restoration activities in the estuary; results of the study are expected to provide valuable data on the potential synergistic effects of the management actions presented in the estuary recovery plan module. Meanwhile, several actions have the potential to be complementary in their effects, at the very least, and possibly to offer significant synergistic benefits. While it is not possible to identify all such actions, examples include using dredged materials to reduce vessel wake stranding (CRE-6 and CRE-12) or improving access to off-channel habitats by breaching dikes and adjusting flows (CRE-10 and CRE-4). At the same time, management actions need to be sequenced to avoid possible negative synergistic effects, such as by restoring contaminated sites (CRE-22) in off-channel habitat before restoring access to that habitat through dike breaching and flow modifications (CRE-10 and CRE-4). Considering the possible complementary, cumulative, or synergistic effects of management actions and sequencing actions for maximum benefit will be important aspects of implementing the estuary recovery plan module.

What about the lower ranking actions? In many ways, the lower ranking actions are the most difficult to characterize in terms of survival improvements and costs. Low ratings may be due more to a lack of scientific information than a lack of effectiveness. For example, basic changes to the food web in the estuary as a result of increased phytoplankton production or the introduction of aquatic invertebrates may have profound effects on the estuary, but the degree of impact is unknown. These threats must be more fully understood if their contribution to overall ecosystem health is to be determined with accuracy.

What planning tasks remain? The process of developing this estuary recovery plan module pointed to several areas where recovery planning for the estuary could be refined. Additional scientific information about juvenile mortality in the estuary would clarify the ecological significance of the estuary relative to tributaries and the middle and upper mainstem Columbia River. A finer scale analysis of limiting factors, threats, and the benefits of management actions would aid in prioritizing actions and focusing them in the geographical areas where they would be most beneficial. Testing the assumptions underlying the allocation of benefits across management actions would increase the value of survival improvement targets as a planning tool, as would further evaluation of the constraints to implementation of the management actions. Lastly, understanding the potential cumulative or synergistic effects of management actions could lead to implementation decisions that would enhance the benefits of actions. Obtaining more information about these topics—mortality in the estuary, biological effects at a finer level, potential benefits of management actions, and synergistic effects—could represent the next level of planning for salmon recovery in the estuary.

Implementation Issues

Implementation of the 23 actions in the module will require the efforts of a variety of Federal, state, and local agencies, organizations, private enterprises, and citizens. (Some potential implementers have been identified in Table 5-6.) While many of these entities have already been working to identify, prioritize, and implement salmon and steelhead recovery actions, effective implementation of all module actions will require additional coordination.

Goals of coordination include using existing processes, programs, and forums efficiently; ensuring the appropriate scale, scope, and sequencing of projects; coordinating funding; tracking and reporting on implementation progress; coordinating monitoring efforts; and providing data management. In addition, implementing the module will require further evaluation of the constraints associated with the 23 actions as well as consideration of potential cumulative and synergistic effects. Also, implementers of module actions will need to remain abreast of current scientific information and ensure that it is continually incorporated into implementation decisions. Although some elements of these larger processes are in place, additional organizational capacity is necessary if these needs are to be adequately addressed.

Table 5-6 includes a rudimentary schedule for implementing each of the 23 management actions described in Chapter 5, but this schedule will need to be refined as the considerations mentioned above are addressed. The first step in coordinated implementation of the module will be a conversation among all relevant entities and stakeholders to discuss near-term implementation priorities, with a goal of developing a 5-year implementation plan that provides specificity and certainty regarding near-term actions and that identifies lead entities for implementation of specific actions or projects. Given the complexities involved in implementing the full suite of module actions, this conversation also will be an opportunity to explore options for and recommend an organizational structure for coordinating and overseeing implementation of the module. The Lower Columbia River Estuary Partnership, a National Estuary Program established to bring about collaboration, would be an appropriate convener of this discussion.

Education and outreach are important aspects of module implementation. Threats to salmonids in the estuary are likely to continue unabated unless resource users in the Columbia River basin make different choices about consumption and development—choices that may be socially and politically challenging. In the face of social and political obstacles, education is one way of garnering support for implementation of the management actions; in fact, education about stewardship and the ecosystem benefits that implementation would provide is an essential component of the management actions in the module; to the extent possible, these education efforts should be coordinated to create efficiencies.

Relationship of the FCRPS BiOp to the Estuary Module

Drafts of this module were available during the Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) remand collaborative process, which led to the 2008-2018 FCRPS Biological Opinion and Supplemental Comprehensive Analysis (National Marine Fisheries Service 2008a and 2008b). Among the provisions of the 2008 FCRPS Biological Opinion (2008 BiOp) were requirements for the Federal action agencies to

implement habitat improvement and predation control actions in the estuary. Estimates of the survival benefits that would be gained from those actions were included in the 2008 BiOp, and those survival estimates were derived from the allocation of survival improvements among actions in this module.

In February 2010, NMFS issued the 2010 Supplemental BiOp for the FCRPS (National Marine Fisheries Service 2010), which integrated elements from the 2008 BiOp and Adaptive Management Implementation Plan (AMIP). The AMIP included accelerated and enhanced actions to protect Columbia Basin salmon and steelhead, including (1) commitments to additional estuary actions under an agreement with the state of Washington, and (2) efforts to control native predators and invasive species. The AMIP also included enhanced research and monitoring and incorporated specific biological triggers for contingencies linked to unexpected declines in the abundance of listed fish.

The 2010 Supplemental BiOp retained the estimates of survival improvements from estuary habitat and predation control actions that had been incorporated into the 2008 BiOp and that were based on a draft version of this estuary module. The 2010 Supplemental BiOp also summarized and assessed relevant new information that had become available since the 2008 BiOp was issued, including information on climate change, juvenile salmonid use of the estuary and plume, predation, toxics, and ecological interactions between hatchery- and natural-origin fish. The new information summarized in the 2010 BiOp will be useful in informing implementation decisions regarding actions in the module.

Actions in the 2008 BiOp and its 2010 Supplement that relate to estuarine habitat, predation, and flow will contribute to implementation of actions in this module. The module, however, identifies habitat, predation, and flow actions that are larger in scope than the actions that will be implemented under the 2008 BiOp and its 2010 Supplement. NMFS projects that the 2008 BiOp actions related to estuarine habitat, flow, and predation will yield only a portion of the total survival improvements that the estuary module hypothesizes are possible for actions in those categories. The intent of the estuary module was to lay out the full suite of limiting factors and threats affecting the estuary; to identify actions or assessments needed to address—or inform the potential to address—those limiting factors and threats; and to provide a basis for future discussions and societal decisions about recovery efforts in the Columbia River estuary.

Preparation for Decision Making

Chapter 7 is intended to help organize a much-needed conversation about recovery efforts in the estuary, plume, and other ecosystems that salmonids depend on to complete their life cycles. While there are many decisions to be made, perhaps the most important is what our level of effort and commitment will be to improving conditions in the estuary. This boils down to deciding how much we are willing to do to recover salmon and steelhead in the Columbia River basin and how comfortable we are with the sacrifices that will be necessary.

The planning exercises in Chapters 5 and 7 were based on the best available science pertaining to limiting factors and threats. However, although science can help inform the key analyses in these chapters (the identification of management actions, constraints evaluation, survival improvement targets, and cost estimates), it cannot tell us which management actions to implement. This is so partly because of the gaps in our understanding of the physical and biological world of the estuary but also because other

decision-making processes come into play when we make choices about the future and what we most value. Ultimately, the degree to which the estuary module is implemented will be determined by the social and political will of the region, and what current and future residents of the basin are willing to pay for—or do without—in order to return salmon and steelhead to viable levels.

Perhaps the single most important conclusion that can be made about the prioritization of management actions is that threats remain threats to salmonids because tough choices have yet to be made—choices that are difficult because of the myriad conflicting goals of the various public, private, individual, and organizational interests within the Columbia River basin. The variety and extent of those interests are reflected in the high degree of constraint for each of the 23 management actions identified in the recovery plan module. The take-home message from this is that the estuary and plume are crucial to ocean- and stream-type salmonids and that achieving a meaningful boost in survival from these ecosystems will require a major investment and implementation of all 23 management actions, to the extent possible.

CHAPTER 8

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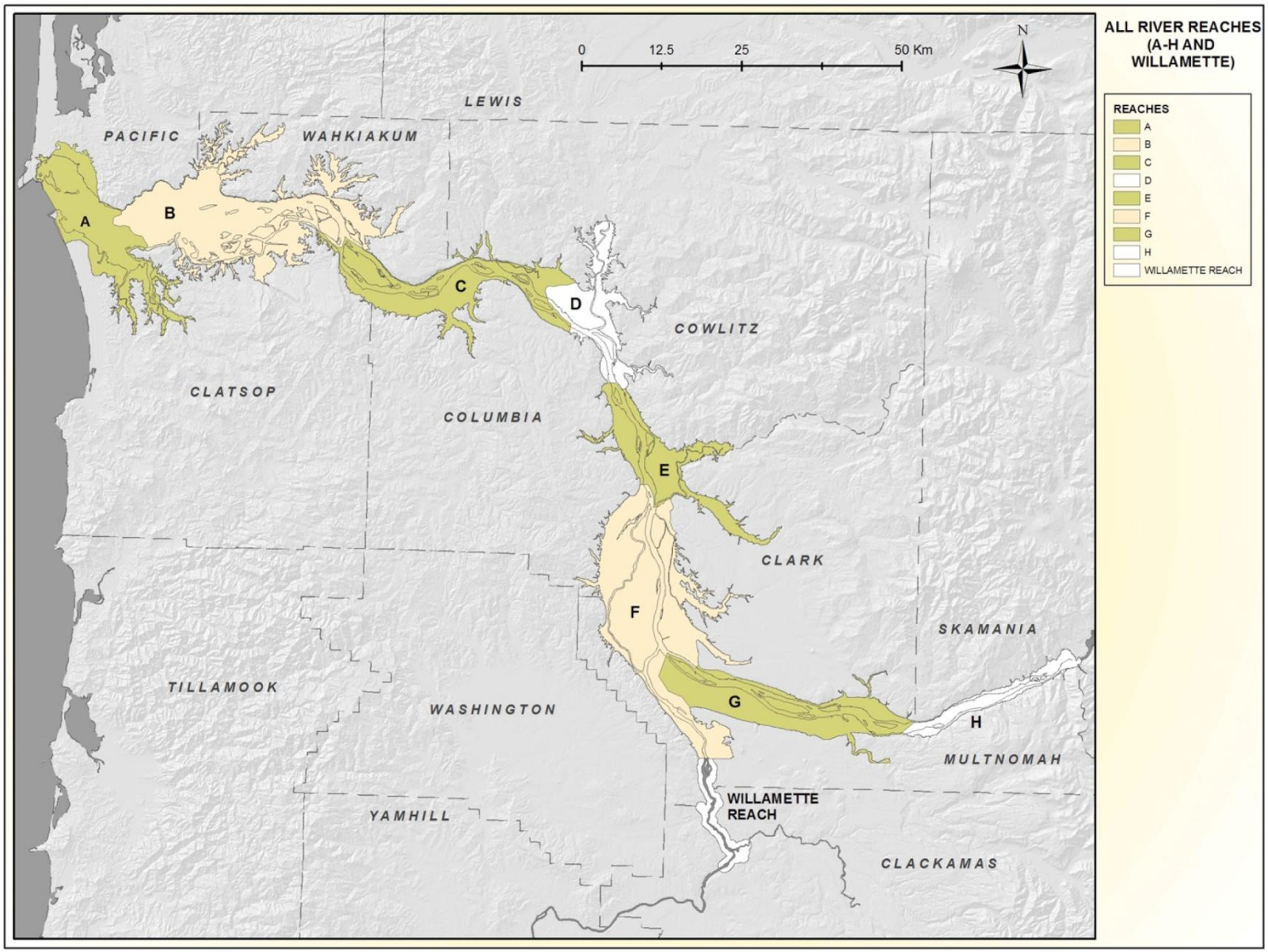
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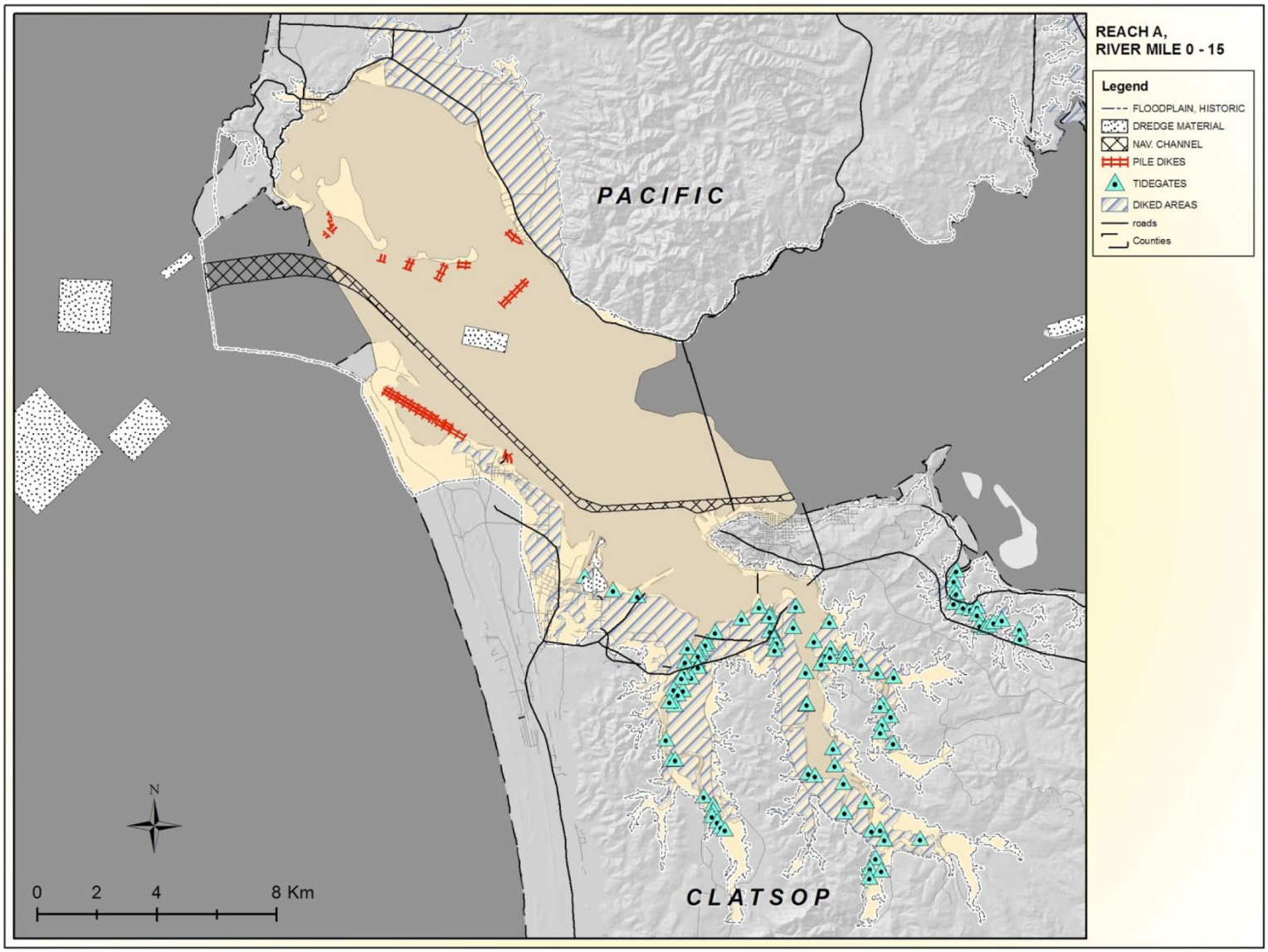
APPENDIX A

Selected Threats to Salmonids by Reach

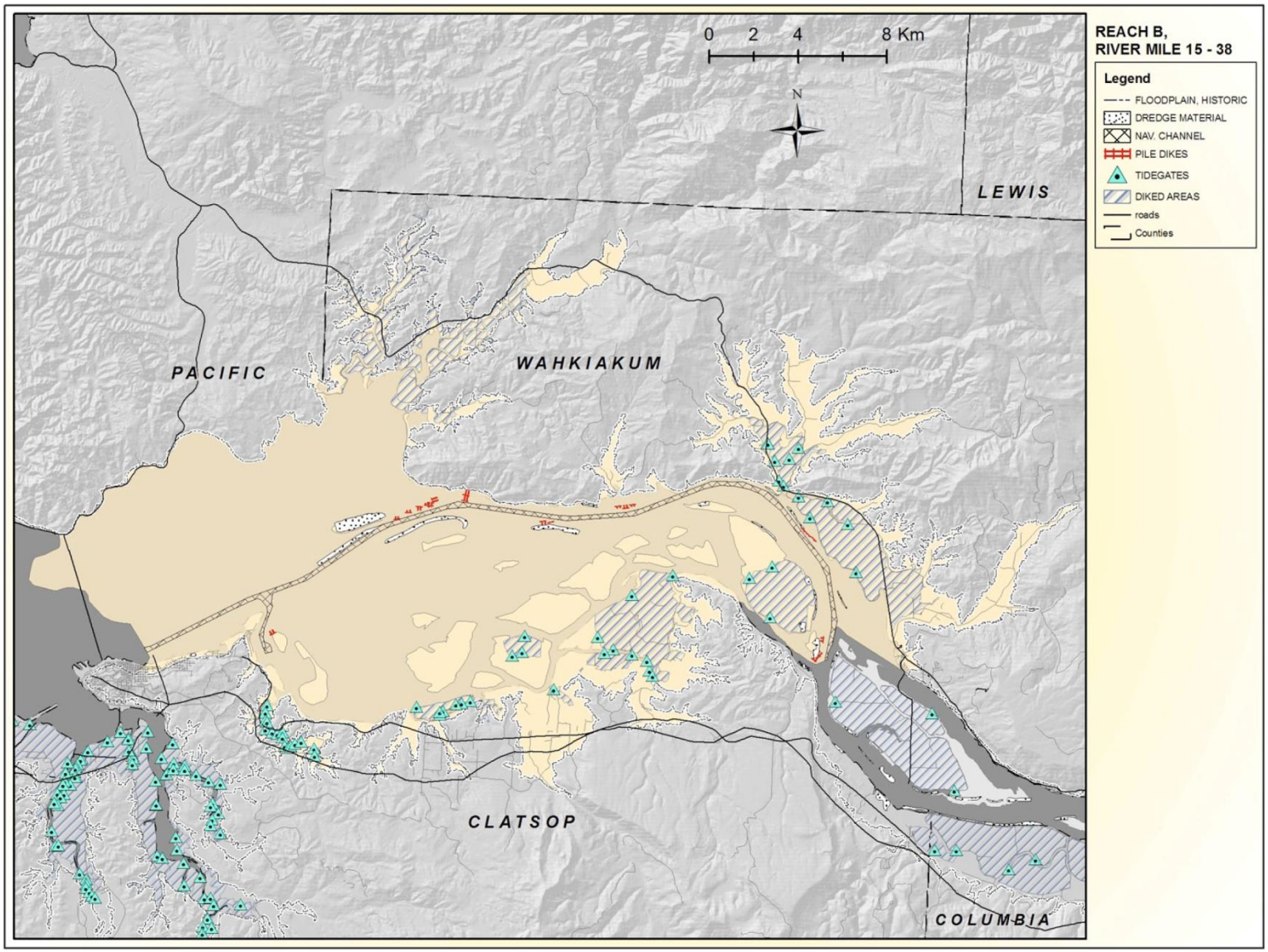
APPENDIX A


ALL RIVER REACHES (A-H AND WILLAMETTE)
REACHES
A
B
C
D
E
F
G
H
WILLAMETTE REACH
0
12.5
25
50 Km
N
LEWIS
PACIFIC
WAHKIAKUM
COWLITZ
CLATSOP
COLUMBIA
CLARK
SKAMANIA
TILLAMOOK
WASHINGTON
MULTNOMAH
YAMHILL
CLACKAMAS
WILLAMETTE REACH

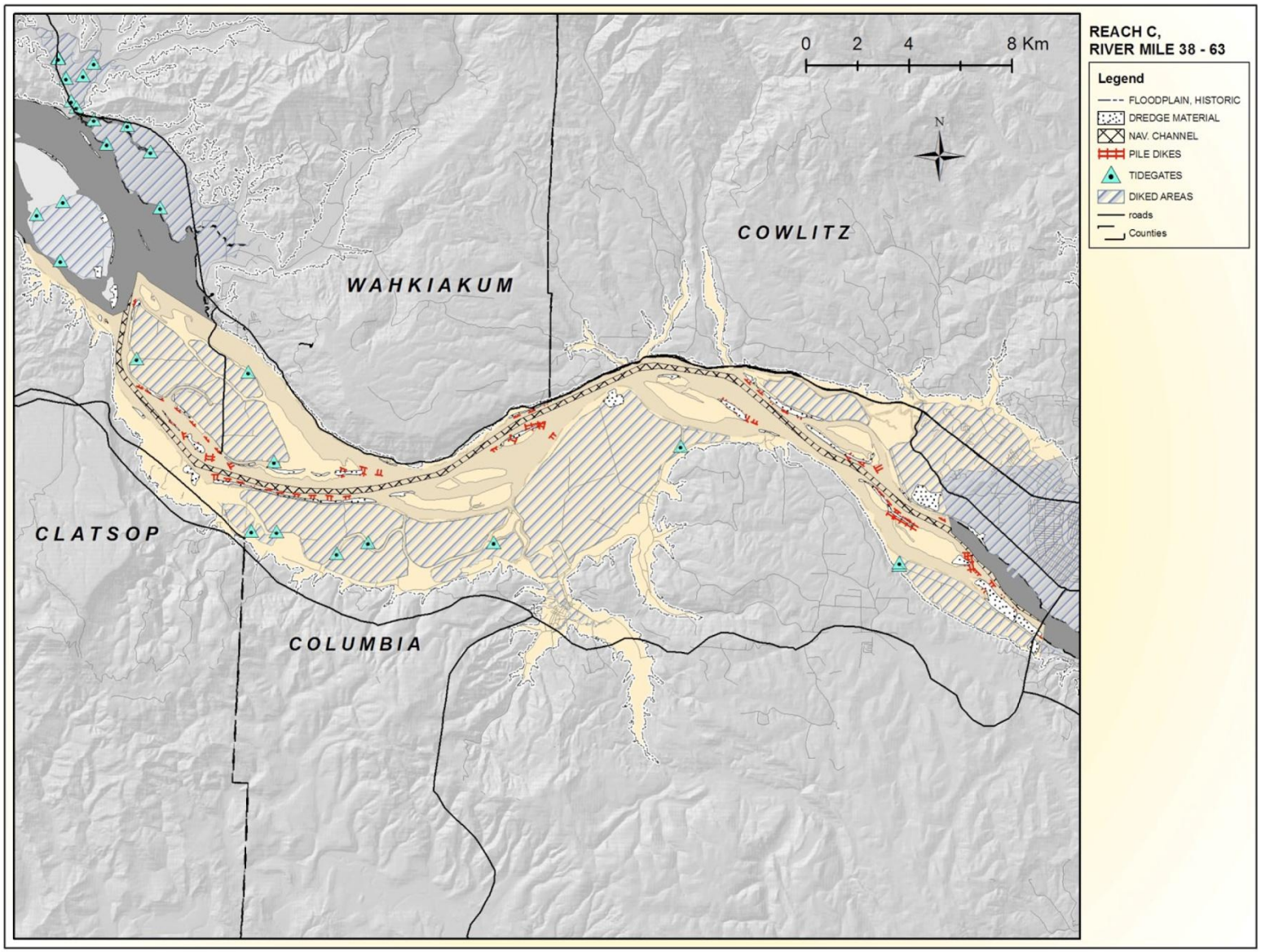
APPENDIX A


REACH A,
RIVER MILE 0 - 15
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
PACIFIC
CLATSOP
N
0
2
4
8 Km

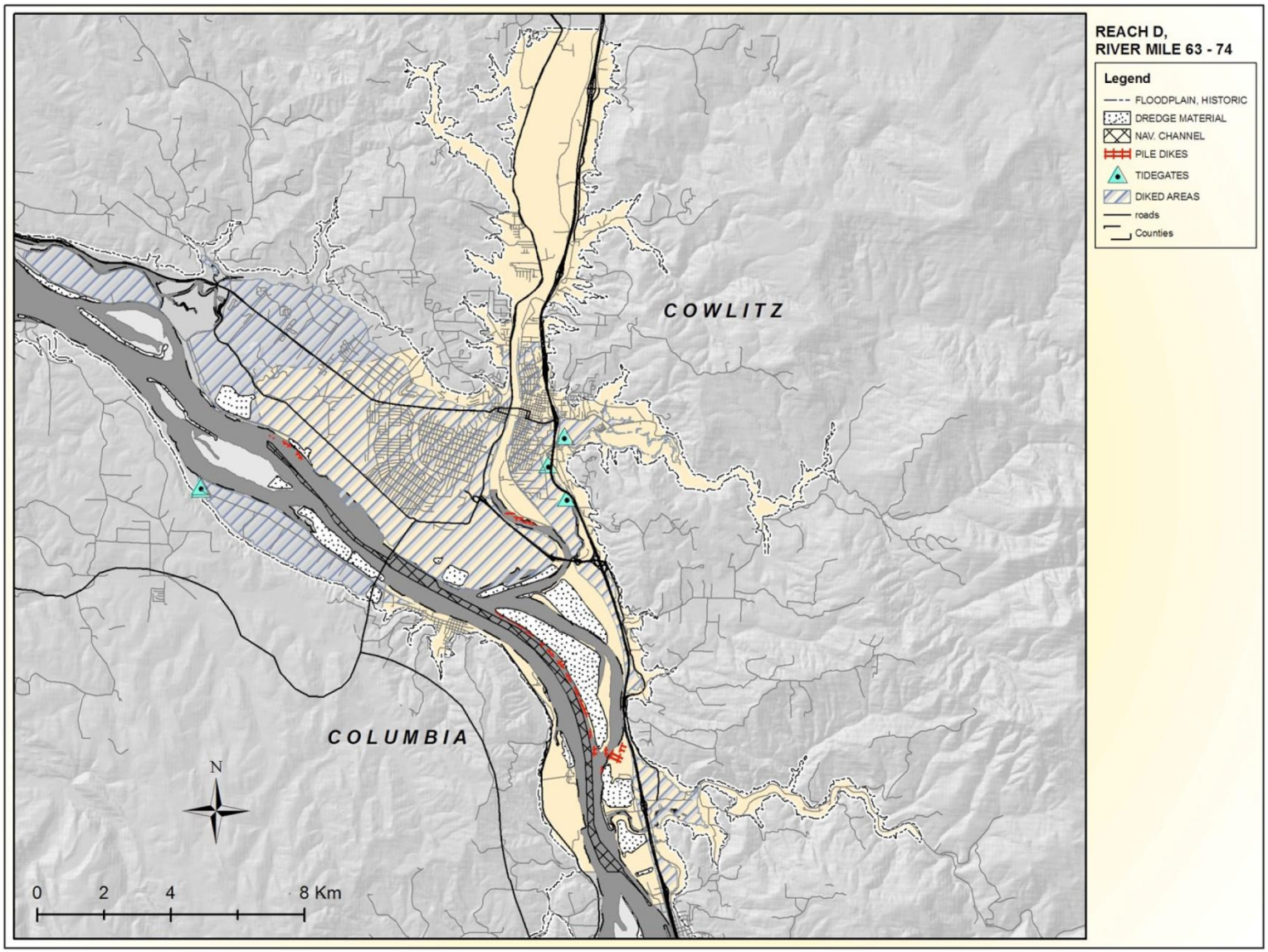
APPENDIX A


0 2 4 8 Km
N
REACH B,
RIVER MILE 15 - 38
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
LEWIS
PACIFIC
WAHKIAKUM
CLATSOP
COLUMBIA

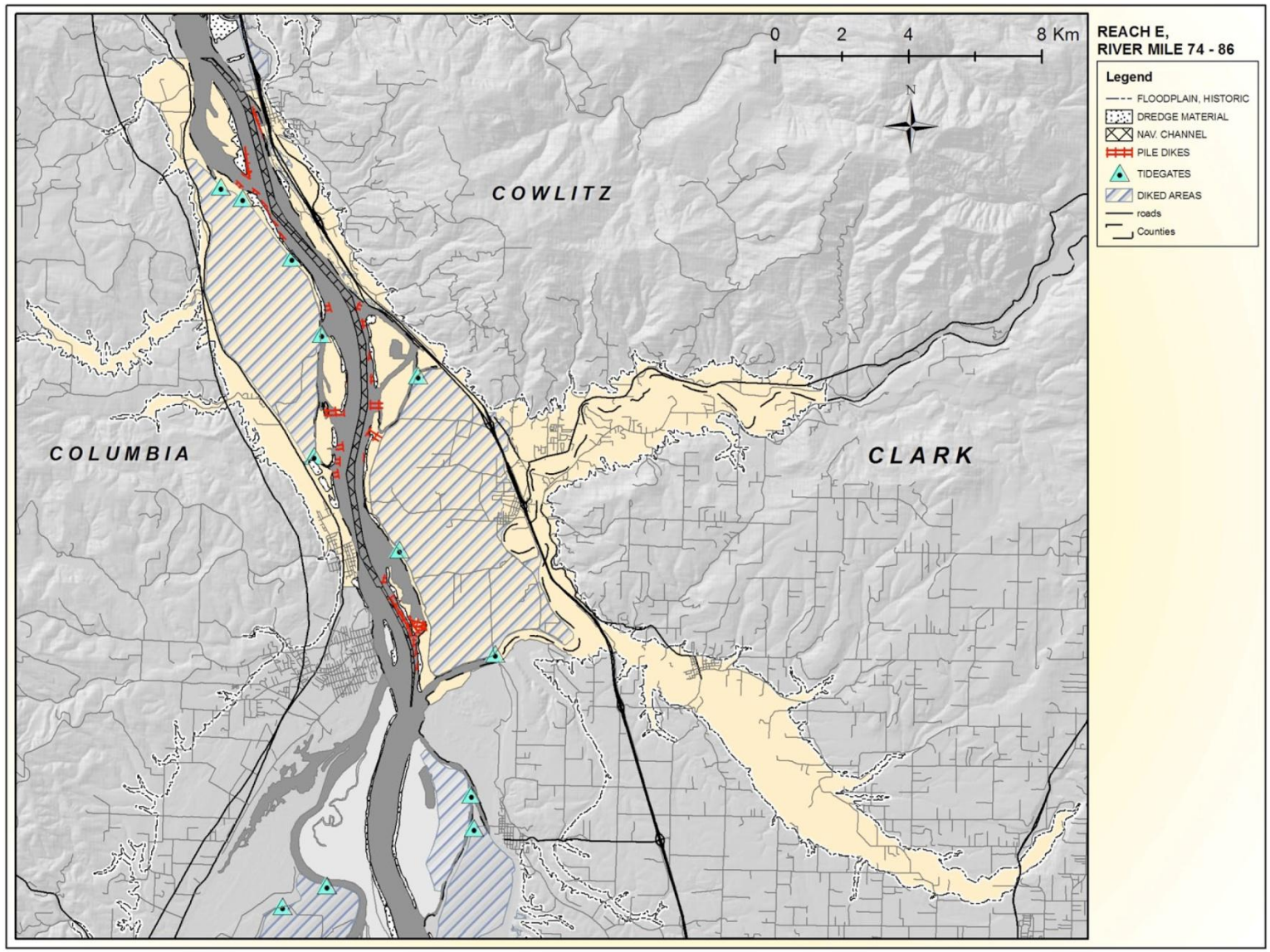
APPENDIX A


REACH C,
RIVER MILE 38 - 63
0 2 4 8 Km
N
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
COWLITZ
WAHKIAKUM
CLATSOP
COLUMBIA

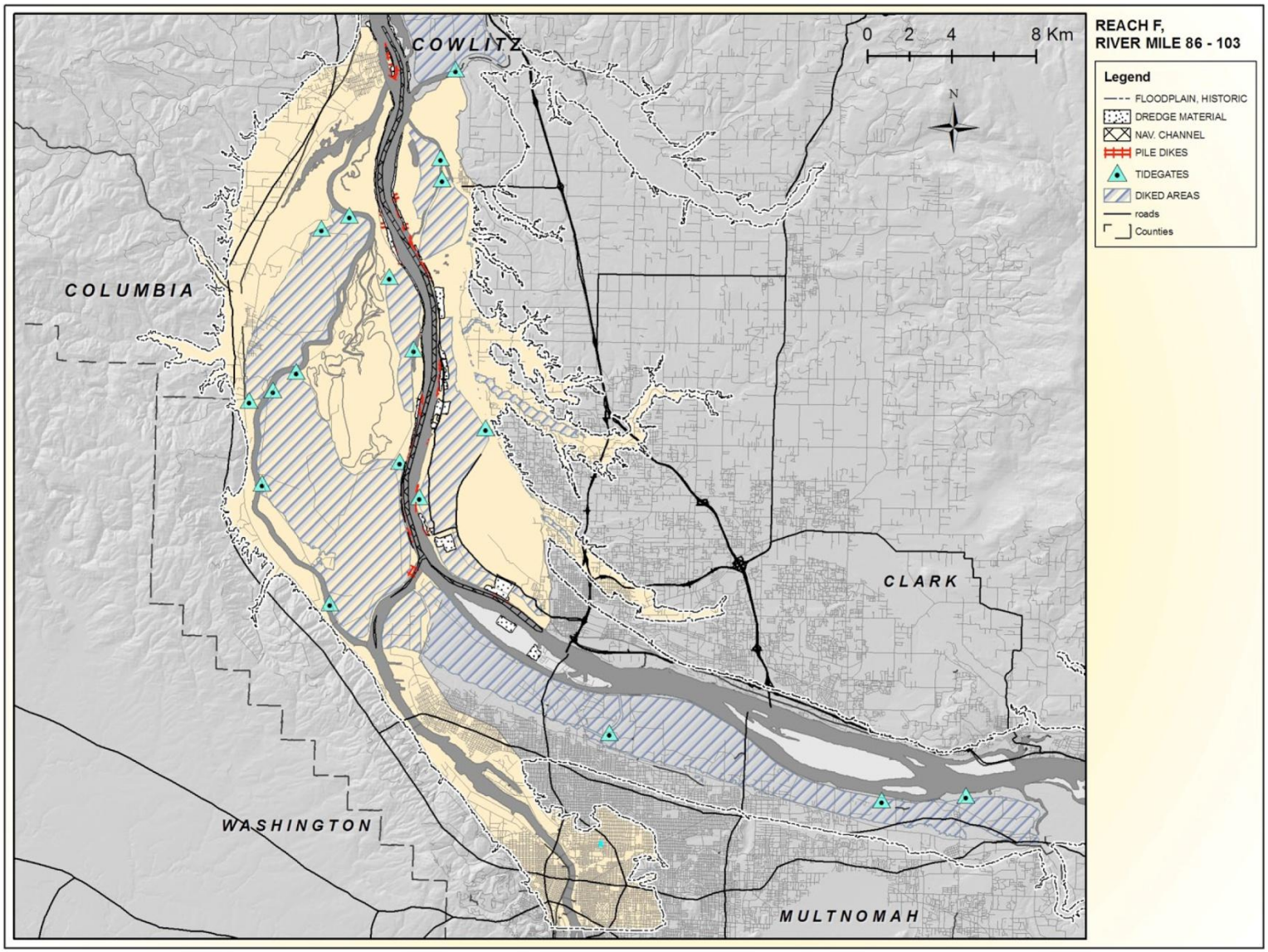
APPENDIX A


REACH D,
RIVER MILE 63 - 74
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
COWLITZ
COLUMBIA
N
0
2
4
8 Km

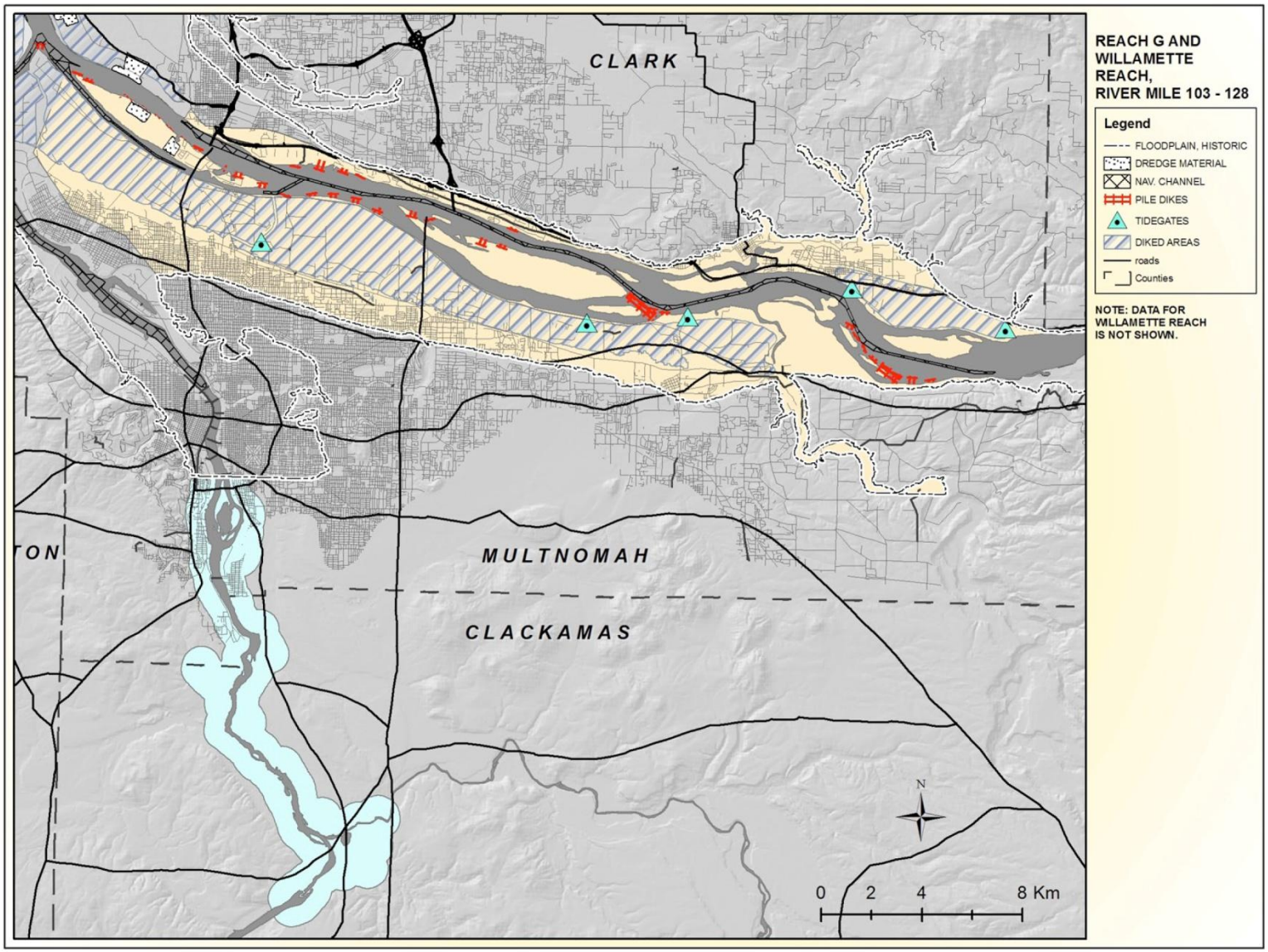
APPENDIX A


0
2
4
8 Km
N
COWLITZ
COLUMBIA
CLARK
REACH E,
RIVER MILE 74 - 86
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties

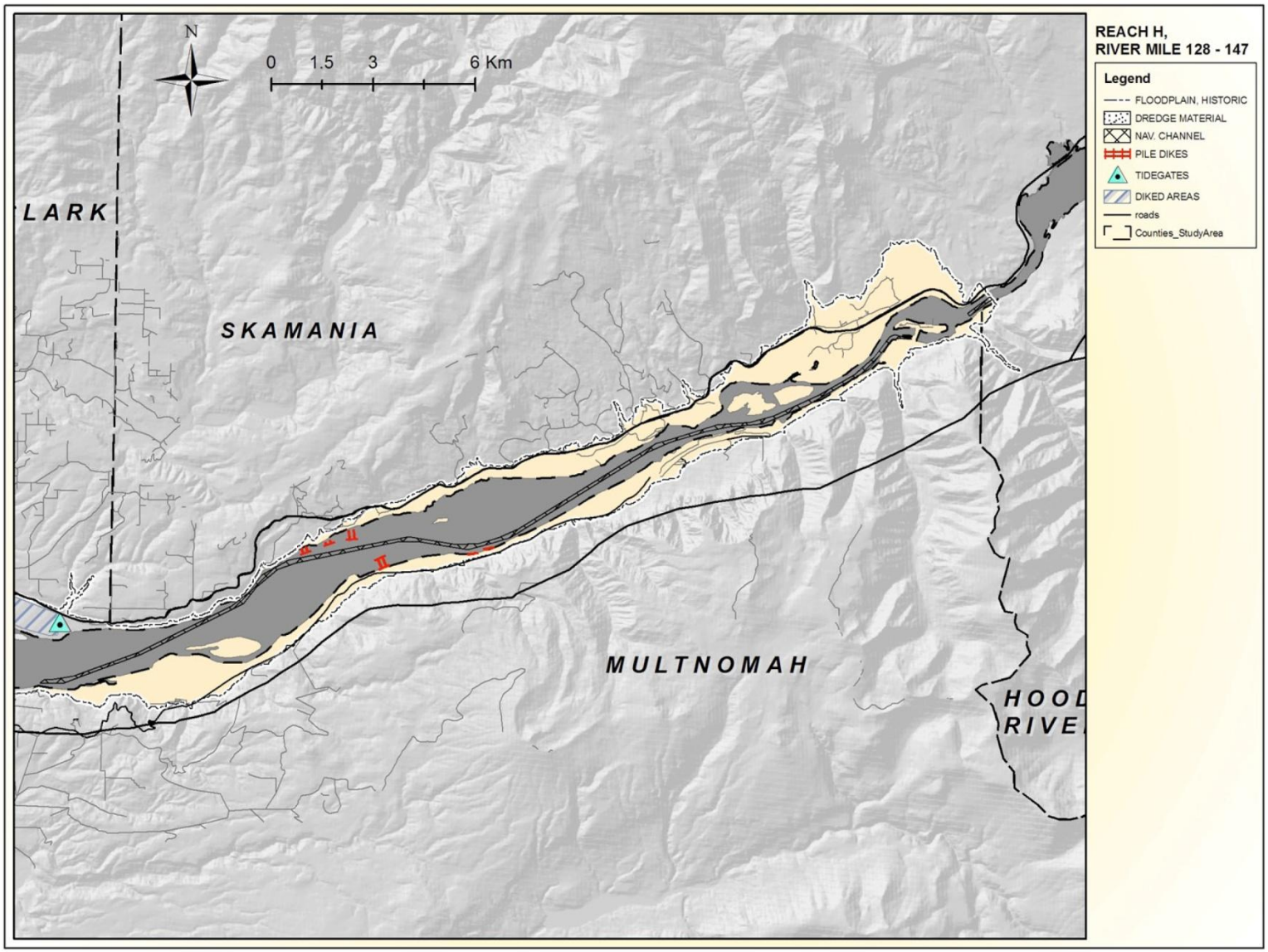
APPENDIX A


COWLITZ
COLUMBIA
CLARK
WASHINGTON
MULTNOMAH
0 2 4 8 Km
N
REACH F,
RIVER MILE 86 - 103
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties

APPENDIX A


CLARK
MULTNOMAH
CLACKAMAS
TON
N
0 2 4 8 Km
REACH G AND WILLAMETTE REACH, RIVER MILE 103 - 128
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
NOTE: DATA FOR WILLAMETTE REACH IS NOT SHOWN.

APPENDIX A


N
0 1.5 3 6 Km
LARK
SKAMANIA
MULTNOMAH
HOOD RIVE
REACH H,
RIVER MILE 128 - 147
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties_StudyArea

APPENDIX A

APPENDIX B

Development of Survival Improvement Targets

APPENDIX B

Development of Survival Improvement Targets

The survival improvement targets in Table 5-5 are a planning tool intended to help initiate a comprehensive discussion about salmonid mortality in the estuary and plume. This tool is an important first step in setting recovery targets for salmonids in the estuary and also for the Columbia River basin. PC Trask & Associates, Inc., developed the survival improvement targets because, in many cases, estimates of mortality resulting from individual limiting factors and of the effectiveness of management actions in reducing threats and limiting factors do not exist. On the other hand, there are reliable estimates of mortality resulting from several of the predators, ship wake stranding, and toxic contamination, and emerging acoustic wire tagging studies are helping to estimate the extent of mortality that juvenile salmonids experience during residency in the estuary.

PC Trask & Associates, Inc., took the following steps to develop the survival improvement targets:

1. Determined the abundance of wild, ESA-listed ocean- and stream-type juveniles entering the estuary using Ferguson (2006b), which estimated 25 million ocean-type juveniles and 14.3 million stream-type juveniles for 2006.

2. Assumed a 50 percent overall juvenile mortality rate for ocean-type salmonids in the estuary and a 40 percent mortality rate for stream-type juveniles. PC Trask & Associates, Inc., reached the 50 percent mortality estimate for ocean type juveniles by taking the 35 percent rate from 2005 micro-acoustic tagging results (Ferguson 2006b) and adding an additional 15 percent to account for smaller ocean-type juveniles not tracked by the study. PC Trask & Associates, Inc., reached the 40 percent mortality estimate for stream-type juveniles by taking the 25 percent rate from the same micro-acoustic tagging study and adding 15 percent to account for presumed deaths occurring in the plume. Continued annual study results will help refine these estimates over time.

3. Used a survival improvement target of 20 percent for both ocean- and stream-type juveniles. The 20 percent number is not scientifically based; instead, it represents a planning target that will require refinement as the extent to which actions are implemented and effective becomes clearer. Survival improvement numbers attempt to reflect wild, ESA-listed fish only. In most cases, known mortality to salmonids (such as from terns) does not break out wild fish from hatchery fish or ESA-listed fish from non-listed fish.

4. Allocated the two targets described above across 22 actions (CRE-14, "Reduce predation by pinnipeds," was treated separately for adult mortality), based on an extensive literature review and personal communication with various agency staff. PC Trask & Associates, Inc., evaluated each action using limiting factor information from Chapter 3, threat information from Chapter 4, and action evaluations from Chapter 5. As a result, the allocation takes into consideration a combination of factors, including the magnitude of the limiting factor, the degree of the associated threat(s), how well the action

addresses the threat, how constrained implementation of the action is likely to be, and the assumption that a considerable level of effort will be applied to implementing each action.

5. Assigned survival improvement targets on a relative scale across all of the actions. The reader should not view the survival improvement targets as an absolute numerical result for each action, but rather a relative indication of the importance of each action. In cases where the scientific community has determined the mortality associated with a particular limiting factor and developed a management plan with mortality reduction goals, such as with predation by Caspian terns, PC Trask & Associates, Inc., used these numbers to the degree possible.

Survival improvement targets are intended to be correlated with cost estimates presented in Table 5-6 for constrained implementation of the management actions. The resulting cost/survival estimates (see Table 7-5) are intended to initiate discussions about the validity of cost estimates and potential survival improvement targets; the cost/survival index values in Table 7-5 are highly uncertain because of the gross assumptions on both sides of the equation.

Disclaimer: Survival improvement numbers are for illustration only and are intended to demonstrate social choices in the face of significant uncertainty. Literature sources generally do not prescribe actions, and relatively few actions have been specifically evaluated for associated survival estimates.

Table B-1
Notes on Development of Survival Improvement Targets

Action	Notes
CRE-1: Protect/restore riparian areas.	Estimate is unsupported in the literature. Estimate was assigned a high value in recognition of its importance relative to food sources and shoreline habitats. This is a protection action that is intended to reduce the potential for increased threat over time.
CRE-2: Operate the hydrosystem to reduce reservoir heating.	Estimate is unsupported in the literature. Estimate was assigned a relatively high value because temperatures commonly exceed 19 degrees Celsius and are doing so more frequently and for longer periods of time. (Nineteen degrees Celsius is considered the upper range of survival for salmonids). Estimate is based on a relatively large level of effort to reduce the threat. It is likely that mitigation will be required in tributaries to implement the action.
CRE-3: Protect/enhance instream flows influenced by withdrawals and other water management actions in tributaries.	Estimate is unsupported in the literature. This is a protection action that is intended to reduce the potential for increased threat. Estimate is closely aligned with CRE-4 and probably has overlapping benefits.

CRE-4: Adjust the timing, magnitude, and frequency of hydrosystem flows.	Estimate is unsupported in the literature. The action affects nearly every facet of estuary ecosystem health. Estimate is intended to demonstrate that changes to the hydrograph are possible and that small increments of change may produce a significant survival improvement. This action is worthy of further analysis that may help support a more defensible survival estimate.
CRE-5: Mitigate entrapment of fine sediment in reservoirs.	Estimate is unsupported in the literature. Estimate was assigned a low survival improvement because of the high degree of uncertainty about its potential to improve salmonid survival. Entrapment of sediment may have significantly larger effects.
CRE-6: Use dredged materials beneficially.	Estimate is unsupported in the literature. Estimate was assigned a low survival improvement because of the high degree of uncertainty about its potential to improve salmonid survival. Currently, beneficial uses are most often associated with nearshore erosion management, and little is known about potential benefits to salmonids in the nearshore.
CRE-7: Reduce entrainment/ habitat effects of dredging and ballast.	Estimate is unsupported in the literature. Estimate is relatively low because of the uncertainty and lack of mortality documentation associated with entrainment.
CRE-8: Remove or modify pilings and pile dikes	Estimate is unsupported in the literature. Estimate is relatively high because of the number of pile dikes in the estuary and the suspected predation effects that result from the threat, including predation by cormorants, pikeminnow, bass, walleye, and catfish. Altered flow circulation and reduced juvenile access to low-velocity habitats may also be a threat.
CRE-9: Protect/restore high-quality off-channel habitat.	Estimate is unsupported in the literature. This is a protection action that is intended to reduce the potential for increased threat. The high estimate reflects the magnitude of importance that off-channel habitats represent to juveniles, especially ocean types. Because restoration activities are highly constrained, it is vital not to lose additional functioning habitats. Protection alone will only help preserve the status quo.
CRE-10: Breach, lower, or relocate dikes and levees.	Estimate is unsupported in the literature. Estimate is intended to demonstrate that dike or levee breaching is one of the top few actions that will increase ocean-type survival in the estuary. If substantial improvements for ocean-type life histories in the estuary are to occur, this is one of a handful of actions that must be implemented. Estimate assumes a significantly higher level of implementation than what is currently occurring.
CRE-11: Reduce over-water structures.	Estimate is unsupported in the literature. Estimate is relatively high because of the number of over-water structures in the estuary and the suspected predation effects that result from the threat, including predation by cormorants, pikeminnow, bass, walleye, and catfish. Other effects, such as decreased light penetration, are not well understood.

CRE-12: Reduce vessel wake stranding.	Mortality estimates for test sites have demonstrated a wide range of confirmed mortality. In Bauersfeld (1977), an assessment of five test sites estimated approximately 150,000 stranded juveniles (on those sites). No estuary-wide estimates have been developed. The emerging availability of LIDAR imagery for the estuary may provide for analysis to extrapolate confirmed site-specific information to estuary-wide predictions. Estimate is relatively high within the range of study estimates.
CRE-13: Manage pikeminnow and other piscivorous fish.	Estimate is unsupported in the literature. Some information exists about predation rates. The threat does not currently appear to be on the increase. Estimate is relatively high based upon conjecture by the NMFS Northwest Fisheries Science Center regarding pikeminnow predation rates, but the threat should be studied further and monitored over time.
CRE-14: Reduce predation by pinnipeds.	An estuary-wide mortality estimate is unsupported in the literature. Estimates are for adults only. Annual counts at Bonneville Dam indicate between 0.4 percent and 3.4 percent mortality of spring Chinook and winter steelhead. A 500-pound Stellar sea lion consumes about 40 to 60 pounds of fish each day. An unsubstantiated estimate of all pinniped predation in the estuary of approximately 10 percent of spring Chinook and winter steelhead is probably reasonable.
CRE-15: Reduce invasive plants.	Estimate is unsupported in the literature. Noxious weeds alter food webs and habitat and work at the ecosystem scale. Very little is understood about the connection between noxious weeds and juvenile salmonid survival. Estimate is relatively high for noxious weeds compared to other ecosystem-scale threats because, although associated actions are difficult, they have a greater likelihood of success than do actions to address other similar threats, such as invertebrate infestations.
CRE-16: Redistribute Caspian terns.	Estimate is supported by the literature. Recent successes in relocating terns have been documented. Efforts to implement the action are under consideration. Estimated mortality attributed to Caspian tern predation is approximately 3.6 million juveniles in 2005. Current planning calls for a two-thirds reduction in the East Sand Island nesting.

CRE-17: Redistribute cormorants.	Estimate is supported by the literature. Efforts to manage cormorants are not nearly as mature as efforts to manage terns. There is less certainty about implementation potential because cormorants have not responded to management efforts to the degree that terns have. Estimated mortality attributable to predation by double-crested cormorants is considered to be comparable to that of predation by terns. Assignment of the target survival improvement was lower than for terns because cormorants may be harder to manage than terns.
CRE-18: Reduce shad abundance.	Estimate is unsupported in literature. Estimate is low because of the high degree of uncertainty about the relationship between shad, salmonids, and ecosystem health. Estimate is also low because the literature does not identify potential actions to reduce shad abundance levels.
CRE-19: Prevent aquatic invertebrate introductions.	Estimate is unsupported in the literature. Extent of the threat is well-documented; however, invertebrate infestations occur at the ecosystem scale, and the degree of mortality that occurs because of food web changes at this scale is unknown. Estimate is relatively low because of the uncertainty of the threat and the inherent challenges of reducing the threat.
CRE-20: Implement pesticide/fertilizer BMPs.	Emerging literature (Loge et al. 2005) hypothesizes that mortality resulting from estuary contamination ranges from 1.5 percent to 9 percent, depending on the amount of time juveniles spend in the estuary. Estimates for CRE-21, CRE-22, and CRE-23 form the basis for survival improvements (using estimates from Loge et al. 2005).
CRE-21: Identify and reduce sources of pollutants.	Emerging literature (Loge et al. 2005) hypothesizes that mortality resulting from estuary contamination ranges from 1.5 percent to 9 percent. Estimates for CRE-20, CRE-22, and CRE-23 form the basis for survival improvements (using estimates from Loge et al. 2005).
CRE-22: Restore or mitigate contaminated sites.	Emerging literature (Loge et al. 2005) hypothesizes that mortality resulting from estuary contamination ranges from 1.5 percent to 9 percent. Estimates for actions CRE-20, CRE-21, and CRE-23 form the basis for survival improvements (using estimates from Loge et al. 2005).
CRE-23: Implement stormwater BMPs.	Estimate is unsupported in the literature. This is a protection action that is intended to reduce the potential for increased threat. This action does not assume retrofitting of existing stormwater function.

ESA Recovery Plan for the White Salmon River Watershed

June 2013

Prepared by
National Marine Fisheries Service
Northwest Region

DISCLAIMER

Endangered Species Act (ESA) recovery plans delineate reasonable actions which the best available information indicates are necessary for the conservation and survival of listed species. Plans are published by the National Marine Fisheries Service (NMFS), usually with the assistance of recovery teams, state agencies, local governments, salmon recovery boards, non-governmental organizations, interested citizens of the affected area, contractors, and others. ESA recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the Plan formulation, other than the NMFS. They represent the official position of NMFS only after they have been signed by the Northwest Regional Administrator. ESA recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions.

The White Salmon River Watershed Recovery Plan straddles two NMFS Recovery Domains: the lower Columbia/Willamette River Recovery Domain, and the middle Columbia River (MCR) Steelhead Recovery sub-domain of the Interior Columbia River Recovery Domain. As such, the White Salmon River Watershed Recovery Plan is appended to both the lower Columbia/Willamette River and the MCR Steelhead Recovery Plans.

With respect to both the lower Columbia/Willamette River Recovery Plan and the MCR Steelhead Recovery Plan to which the White Salmon Watershed Recovery Plan is appended, where areas of disagreement arose between a management unit plan and a species level, evolutionarily significant unit or distinct population segment plans, NMFS worked with the relevant parties to resolve the differences, and, in a few cases, identified in the evolutionarily significant unit/distinct population segment plans, decided not to incorporate the disputed material in the evolutionarily significant unit or distinct population segment plans. NMFS reserves the right to decide whether or not to incorporate any such disputed materials into the species level plans.

ESA recovery plans provide important context for NMFS determinations pursuant to section 7(a)(2) of the ESA. However, recovery plans do not place any additional legal burden on NMFS or the action agency when determining whether an action would jeopardize the continued existence of a listed species or adversely modify critical habitat. The procedures for the section 7 consultation process are described in 50 CFR 402 and are applicable regardless of whether or not the actions are described in a recovery plan.

Contents

Acronyms and Abbreviations ..... **vii**
Recovery Planning Glossary ..... **ix**
Executive Summary ..... **xv**
1 Introduction **1-1**
1.1 Purpose of Plan 1-2
1.1.1 ESA Requirements 1-3
1.1.2 Coordination with Others 1-3
1.2 Context of Plan Development 1-5
1.2.1 Planning Forum 1-7
1.3 How NMFS Intends to Use the Plan 1-7
2 Biological Background **2-1**
2.1 Populations and Major Population Groups 2-1
2.2 Physical Setting 2-8
2.3 Ecosystem Conditions 2-8
2.3.1 Hydrology 2-9
2.3.2 Migration Barriers 2-10
2.3.3 Riparian Function and Conditions 2-10
2.4 Life History Characteristics 2-11
2.4.1 White Salmon River Chinook salmon 2-11
2.4.2 White Salmon River coho salmon 2-17
2.4.3 Upper Gorge chum salmon 2-19
2.4.4 White Salmon River steelhead 2-21
2.5 Hatchery Production and Releases 2-25
2.6 Harvest 2-27
3 Recovery Goals and Viability Criteria **3-1**
3.1 Recovery Goals 3-1
3.2 Biological Viability Criteria 3-2
3.2.1 ESU/DPS Viability Criteria 3-2
3.2.2 DPS and MPG Viability Criteria 3-10
3.3 Threats Criteria 3-12
4 Current Status Assessment **4-1**
4.1 Risk of Extinction: Willamette/Lower Columbia TRT 4-1
4.2 Extinction Risk: Interior Columbia TRT 4-3
5 Limiting Factors and Threats **5-1**
5.1 Blocked Migration and Impaired Passage 5-2
5.2 Freshwater Habitat 5-3
5.2.1 Lower White Salmon River Habitat Below Condit Dam 5-3
5.2.2 Habitat Upstream of Condit Dam 5-4
5.3 Hatchery Production and Releases 5-6
5.4 Harvest 5-7
5.5 Federal Columbia River Hydrosystem 5-12
5.5.1 Hydro Project Impacts on Outmigrating Smolts 5-13
5.5.2 Hydro Project Impacts on Migrating Adults 5-13
5.6 Predation, Competition and Disease 5-13
5.7 Ocean Conditions 5-14

5.8 Climate Change 5-14
5.9 Other Large-Scale Threats 5-15
6 Recovery Strategy and Actions 6-1
6.1 Salmon and Steelhead Reintroduction Plans 6-1
6.1.1 Fall Chinook salmon 6-2
6.1.2 Spring Chinook salmon 6-3
6.1.3 Coho salmon 6-4
6.1.4 Chum salmon 6-4
6.1.5 Steelhead 6-5
6.1.6 Monitoring and Evaluation 6-6
6.2 Freshwater Habitat Strategies and Actions 6-9
6.2.1 High Priority Reaches for Habitat Protection/Restoration and Proposed Actions 6-16
6.3 Hatcheries 6-19
6.4 Harvest-Related Strategies and Actions 6-19
6.5 Hydro-Related Strategies and Actions 6-20
7 Implementation and Cost Estimates 7-1
7.1 Implementation 7-1
7.2 Costs 7-2
8 Monitoring, Research, and Evaluation for Adaptive Management 8-3
8.1 Designing a Monitoring and Evaluation Program to Support Adaptive Management 8-3
8.2 Adaptive Management 8-4
8.3 Critical Uncertainties 8-4
8.3.1 Research 8-4
8.3.2 In-Watershed Research Needs 8-5
8.3.3 Out-of-Watershed Research Needs 8-5
8.4 Monitoring 8-6
8.4.1 Implementation Monitoring 8-7
8.4.2 Status/Trend Monitoring 8-7
8.4.3 Effectiveness Monitoring 8-8
8.5 Consistency with Other Monitoring Programs 8-8
8.6 Coordination 8-9
8.7 Evaluation Schedule 8-9
8.8 Monitoring and Evaluation Plan 8-10
9 References 9-1
Appendix I. Options for Salmon and Steelhead Reintroduction 1
Appendix II. Current Efforts and Regulations Addressing and Protecting Population Productivity in the White Salmon Watershed 1
Appendix III. Jewett Creek 1
Appendix IV. White Salmon River Implementation Schedule: Summary of Actions and Potential Costs to Restore White Salmon River Anadromous Fish Populations and Their Habitat 1

List of Figures

Figure ES-1. White Salmon watershed in Washington State (NPCC 2004) xviii

Figure 1-1. White Salmon watershed in Washington State 1-2

Figure 2-1. Historical fall and late fall demographically independent populations in the Lower Columbia River Chinook salmon ESU (Myers et al. 2006) 2-2

Figure 2-2. Historical spring demographically independent populations in the lower Columbia River Chinook salmon ESU (Myers et al. 2006) 2-3

Figure 2-3. Historical demographically independent populations in the lower Columbia River Coho salmon ESU (Myers et al. 2006) 2-4

Figure 2-4. Historical demographically independent populations in the Columbia River chum salmon ESU (Meyers et al. 2006) 2-5

Figure 2-5. Historical summer and winter steelhead populations in the middle Columbia River DPS (ICTRT 2004; ICTRT 2007b). Note populations in gray are extirpated or functionally extirpated 2-7

Figure 2-6. White Salmon River watershed topography and hydrology (NPCC 2004) 2-9

Figure 2-7. Wild and total tule fall Chinook salmon escapement for the White Salmon River from 1992-2003 (USFWS 2004) 2-12

Figure 2-8. Possible extent of historic spawning distribution of Chinook salmon in the White Salmon River (NPCC 2004) 2-14

Figure 2-9. Potential extent of historical spawning distribution of coho salmon in the White Salmon River (McElhany et al. 2004) 2-18

Figure 2-10. Major Population Groups (MPGs) and populations of middle Columbia steelhead. Note the White Salmon steelhead population is considered functionally extirpated (ICTRT 2007b)2-22

Figure 3-1. Hierarchical levels of salmonid population structure as defined by the TRTs for ESU/DPS recovery planning 3-3

Figure 3-2. Example of an abundance/productivity viability curve (ICTRT 2007a) 3-10

Figure 4-1. Intrinsic habitat potential and Major Spawning Area for the White Salmon River summer/winter steelhead (ICTRT 2008) 4-5

Figure 8-1. NMFS Listing Status Decision Framework 8-3

List of Tables

Table ES-1. ESA listed DPS/ESU in the White Salmon River xvi

Table ES-2. Recovery Strategies and Actions for White Salmon River Salmon and Steelhead Populations xxix

Table 2-1. Key habitat by life stage and time period for fall/spring Chinook salmon (NPCC 2004) ... 2-15

Table 2-2. Key habitat by life stage and time period for White Salmon River coho salmon 2-19

Table 2-3. Key habitat by life stage and time period for steelhead (NPCC 2004) 2-24

Table 3-1. Population viability criteria (McElhany et al. 2003; McElhany et al. 2006)..... 3-5

Table 3-2. Population persistence*/viability categories (McElhany et al. 2003; McElhany et al. 2006) 3-7

Table 3-3. Criteria guidelines for determining strata and ESU viability (McElhany et al. 2003, 2006) . 3-8

Table 4-1. Evaluation scores for White Salmon fall-run Chinook salmon (McElhany et al. 2004)..... 4-1

Table 4-2. Evaluation scores for White Salmon spring-run Chinook salmon (McElhany et al. 2004) ... 4-2

Table 4-3. Evaluation scores for White Salmon coho salmon (McElhany et al. 2004)..... 4-2

Table 4-4. Evaluation scores for upper Gorge chum salmon (McElhany et al. 2004)..... 4-3

Table 5-1. River miles of salmon and steelhead habitat above and below Condit Dam (NPCC 2004) .. 5-3

Table 5-2. Primary limiting factors for lower Columbia River fall Chinook salmon in the White Salmon River drainage 5-16

Table 5-3. Additional factors potentially limiting anadromous fish (lower Columbia River spring Chinook salmon and coho salmon, Columbia River chum salmon, and middle Columbia River steelhead in the White Salmon River drainage). The primary limiting factors are highlighted in light yellow; factors that may become limiting in the future are highlighted in light gray..... 5-17

Table 6-1. Biological objectives, management strategies, and actions to enhance/reintroduce anadromous salmonid populations and acquire baseline habitat information in the White Salmon River Basin..... 6-8

Table 6-2. Primary biological objectives, management strategies, and actions to improve habitat in the White Salmon River watershed..... 6-11

Table 6-3. Biological objectives, management strategies, and actions to improve habitat in the upper White Salmon River watershed..... 6-12

Table 6-4. Summary table addressing hatchery, harvest and hydrosystem-related recovery strategies and actions..... 6-21

Table 7-1. Summary of potential costs to restore the White Salmon River fish populations and their habitat 7-2

Detailed cost breakdown by specific action..... AIV-2

Acronyms and Abbreviations

BIA	Bureau of Indian Affairs
BKD	Bacterial Kidney Disease
BPA	Bonneville Power Administration
BMP	Best Management Practice
CAO	Critical Areas Ordinance
CBFWA	Columbia Basin Fish and Wildlife Authority
CEO	County Environmental Ordinance
cfs	cubic feet per second
CSMEP	Collaborative System-wide Monitoring and Evaluation Project
CWT	Coded wire tag
CUP	Conditional Use Permits
CR	Columbia River
CZO	County Zoning Ordinance
DNA	Deoxyribonucleic Acid
DPS	Distinct Population Segment
EDT	Ecosystem Diagnosis and Treatment
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESHB	Engrossed Substitute House Bill
ESU	Evolutionarily Significant Unit
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FMEP	Fisheries Management and Evaluation Plan
FMP	Forest Management Plan
FPO	Floodplain Management Ordinance
GIS	Geographic Information System
HCD	Habitat Conservation Plan
HGMP	Hatchery and Genetic Management Plans
HCD	Habitat Conservation Plan
ICTRT	Interior Columbia Technical Recovery Team
IHN	Infectious Hemotapoietic Necroses
ISAB	Independent Scientific Advisory Board
km	kilometer
LCR	Lower Columbia River
LCFRB	Lower Columbia Fish Recovery Board
LUMA	Land Use Management Area
LWD	Large Woody Debris
LWS	Little White Salmon
MaSA	Major Spawning Area
MCR	Middle Columbia River
MCRFEG	Middle Columbia River Fisheries Enhancement Group
MEA	Management Emphasis Area

MPG	Major Population Group
NEPA	National Environmental Policy Act
NFH	National Fish Hatchery
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPDES	National Pollution Discharge Elimination System
NPPC	Northwest Power Planning Council
NRC	National Research Council
NRCS	Natural Resources Conservation Service
O&M	Operation and Maintenance
ODFW	Oregon Department of Fish and Wildlife
PCSRF	Pacific Coastal Salmon Recovery Fund
PFMC	Pacific Fisheries Management Council
PIT	Passive Integrated Transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
RCW	Revised Code of Washington
RM	River-Mile
RM&E	Research, Monitoring, and Evaluation
RPA	Reasonable and Prudent Alternative
SEPA	State Environmental Policy Act
SMP	Shorelines Master Plan
SRFB	Salmon Recovery Funding Board
SSB	Substitute Senate Bill
TMDL	Total Maximum Daily Load
TRT	Technical Recovery Team
TUs	Thermal Units
UCD	Underwood Conservation District
URB	Upriver Bright
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geographic Survey
VSP	Viable Salmonid Population
WAGIT	Washington Gorge Implementation Team
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WDOE	Washington Department of Ecology
WRIA	Water Resource Inventory Area
W/LC TRT	Willamette/Lower Columbia Technical Recovery Team
YN	Yakama Nation, also Confederated Tribes and Bands of the Yakama Nation

Recovery Planning Glossary

Abundance: In the context of salmon recovery, unless otherwise qualified, abundance refers to the number of adult fish returning to spawn.

Adaptive management: Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. An overall implementation plan incorporates a monitoring, evaluation, and feedback framework in which the results of actions become feedback on design and implementation of future actions.

Anadromous fish: Species hatched in freshwater, migrate to and mature in salt water, and return to freshwater to spawn.

Baseline monitoring: In the context of recovery planning, scientists conduct baseline monitoring to establish historical and/or current conditions to measure progress (or lack of progress).

Broad-sense recovery goals: Goals defined in the recovery planning process, that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values. Local recovery planning groups usually developed these goals.

Compliance monitoring: Determining whether recovery implementation or actions are meeting a specific performance standard, environmental standard, regulation, or law.

Delisting criteria: Criteria incorporated into Endangered Species Act (ESA) recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a National Marine Fisheries Service (NMFS) determination and may include both technical and policy considerations.

Diel flow: Flow that occurs during a 24-hour period.

Distinct Population Segment (DPS): A listable entity under the ESA that meets tests of discreteness and significance according to U.S. Fish and Wildlife Service (USFWS) and NMFS policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.

Diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy *v*. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size,

developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.

Effectiveness monitoring: Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?

ESA recovery plan: A plan to recover a species listed as threatened or endangered under the U.S. ESA. The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the Plan's goals; and (3) estimates of the time required and costs to implement recovery actions.

Evolutionarily Significant Unit (ESU): A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species.

Extinct: There are no individuals of this former population or species anywhere.

Extirpated: Zero population or individuals in a certain area but conspecifics exist elsewhere.

Factors for decline: Five general categories of causes for decline of a species, listed in the ESA section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence.

Functionally extirpated: A species or population that has been extirpated from an area; although a few individuals may occasionally be found, they are not thought to constitute a population.

Hyporheic zone: Area of saturated sediment and gravel beneath and beside streams and rivers where groundwater and surface water mix.

Implementation monitoring: An examination to determine whether the responsible public or private implementing entity performed the activity and/or completed it as planned.

Independent population: Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.

Indicator: A variable used to forecast the value or change in the value of another variable.

Integrated hatchery program: The purpose of an integrated hatchery program is to increase abundance, while minimizing the genetic divergence of a hatchery broodstock from a naturally spawning population. To maintain the genetic characteristics of a local, natural population among hatchery-origin fish, an integrated program attempts to minimize the genetic effects of domestication. The expected result is a reduction of the genetic risks that hatchery-origin fish may pose to the naturally spawning population.

Interim regional recovery plan: A recovery plan intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.

Intrinsic potential: The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

Intrinsic productivity: The expected ratio of natural-origin offspring to parent spawners at levels of abundance below carrying capacity.

Kelts: Steelhead that are returning to the ocean after spawning and have the potential to spawn again in subsequent years (unlike most salmon, steelhead do not necessarily die shortly after spawning).

Large Woody Debris (LWD): A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.

Legacy effects: Impacts from past activities that continue to affect a stream or watershed in the present day.

Limiting factor: Physical, biological or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that result in reductions in Viable Salmonid Population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach its desired status.

Locally developed recovery plan: State, tribal, regional, and local planning entities throughout the region drafted plans to address the ESA as well as other mandates and recovery needs. Local and regional citizen and business groups were also involved in these planning efforts.

Maintained status: Population status in which the population does not meet viability criteria but does support ecological functions and preserve options for ESU/DPS recovery.

Major Population Group (MPG): A group of salmonid populations that is geographically and genetically cohesive. The MPG is a level of organization between demographically independent populations and the ESU or DPS.

Management Unit: A geographic area defined for recovery planning purposes on the basis of state, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU or DPS.

Metrics: Quantification of a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.

Morphology: The form and structure of an organism, with special emphasis on external features.

Natural-origin fish: Fish spawning and rearing in the wild, regardless of parental origin.

Parr: The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.

Phenotype: Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties or behavior.

Piscivorous: (Adj.) Describes fish that eat other fish.

Productivity: The average number of surviving offspring per parent. Used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over an entire life cycle. Often expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

Recovery domain: A NMFS-defined administrative unit for recovery planning based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.

Recovery goals: Goals incorporated into a locally developed recovery plan, which may include recovery, delisting, reclassification, and/or other goals. Broad-sense goals are a subset of recovery goals.

Recovery plan supplement: A NMFS supplement to a locally developed recovery plan that describes how the plan addresses ESA requirements for recovery plans. The supplement also proposes ESA delisting criteria for the ESUs addressed by the plan, since a determination of these criteria is a NMFS decision.

Recovery scenarios: Scenarios that describe a target status for each population within an ESU, generally consistent with Technical Recovery Team (TRT) recommendations for ESU viability.

Redd: A female salmonid constructs a nest, or redd, in streambed gravels where she deposits her eggs and males fertilize them.

Recovery strategy: Statements that identify the assumptions and logic-the rationale-for the species' recovery program.

Riparian area: Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland.

Salmonid: Fish of the family *Salmonidae*, including salmon, trout, char, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and char.

Segregated hatchery program: The intent of a segregated hatchery program is to maintain a genetically distinct hatchery population. The only way to reduce risk (genetic and ecological) to natural populations from segregated programs is to minimize the contribution of hatchery fish to natural spawning.

Smolt: A juvenile salmonid that is undergoing physiological and behavioral changes to adapt from freshwater to saltwater as it migrates toward the ocean.

Spatial structure: Characteristics of a fish population's geographic distribution. Current spatial structure depends upon the presence of fish, not merely the potential for fish to occupy an area.

Stakeholders: Agencies, groups, or private citizens interested in or affected by recovery planning and/or actions.

Technical Recovery Team (TRT): NMFS convenes work groups, the TRTs, to develop technical products related to recovery planning. Planning forums unique to specific states, tribes, or regions both complement and use TRTs and other technical products to identify recovery actions.

Threats: Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

Viability criteria: NMFS appointed TRTs to define criteria to describe a VSP based on the biological parameters of abundance, productivity, spatial structure, and diversity. NMFS and others use these viability criteria as technical input into the recovery planning process and provide a technical foundation for development of biological delisting criteria.

Viability curve: A curve describing combinations of abundance and productivity that yield a particular risk or extinction level at a given level of variation over a specified time frame.

Viable Salmonid Population (VSP): An independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame.

VSP parameters: Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, *viable salmonid populations and the recovery of evolutionarily significant units*, McElhany et al., June 2000.

Executive Summary

The Endangered Species Act (ESA) of 1973 requires National Oceanic and Atmospheric Administration (NOAA)'s National Marine Fishers Service (NMFS) to develop recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed to restore threatened and endangered species to the point that they are again self-sustaining elements of their ecosystems and no longer need the protections of the ESA. Recovery plans are not regulatory documents; they are guidance for anyone involved in species recovery efforts as well as for the various state, Federal, tribal, and local entities whose activities and jurisdictions may affect endangered species. A recovery plan provides a roadmap for restoring a listed species or population to biological viability and greater likelihood of long-term survival.

This is a plan for re-establishing the White Salmon River populations of lower Columbia River (LCR) Chinook salmon, LCR coho salmon, Columbia River (CR) chum salmon, and MCR steelhead. The Plan aims for these populations to contribute to the conservation and survival of their respective Evolutionarily Significant Units (ESUs)/Distinct Population Segments (DPSs)[1] (Table ES-1).

The White Salmon River fall and spring Chinook salmon are included in the LCR Chinook salmon (*Oncorhynchus tshawytscha*) ESU, which NMFS listed as threatened on March 24, 1999 and reconfirmed June 28, 2005. The ESU includes all naturally spawned populations of Chinook salmon in the CR and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point east of Hood River in Oregon and the White Salmon River in Washington. The White Salmon River spring Chinook salmon are considered extirpated (Good et al. 2005; Myers et al. 2006).

The White Salmon River coho salmon are part of the LCR coho salmon (*Oncorhynchus kisutch*) ESU, which NMFS listed as threatened on June 28, 2005. The ESU includes all naturally spawned coho salmon populations in the CR and its tributaries from the mouth of the CR to a transitional point east of the Hood and White Salmon Rivers. The White Salmon River coho salmon are considered extinct (Good et al. 2005; Myers et al. 2006).

The White Salmon chum salmon are part of the CR chum salmon *(Oncorhynchus keta*) ESU, which NMFS listed as threatened on March 25, 1999. The CR chum salmon ESU includes all naturally spawning populations in the CR and its tributaries in Washington and Oregon. Presently, all CR chum salmon spawning populations are located downstream of Bonneville Dam. Annual fish passage reports (U.S. Army Corps of Engineers (USACE), 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008) for Bonneville Dam provided data that adult

[1] An 'evolutionarily significant unit' (ESU) of Pacific salmon (Waples 1991) and a 'distinct population segment' (DPS) of steelhead (71 FR 834, January 5, 2006) are considered to be 'species,' as defined in section 3 of the ESA.

chum salmon continue to pass upstream of Bonneville Dam, with adult counts averaging 139 and ranging from a low of 46 to high of 411 from 2000 to 2008.

The White Salmon River historically included a population of MCR steelhead (*Oncorhynchus mykiss*). The MCR steelhead DPS is made up of steelhead populations in Oregon and Washington tributaries of the CR upstream of the Hood and Wind River systems, up to and including the Yakima River. The White Salmon steelhead population is considered "functionally extirpated" for the following reasons: the population's current lack of access to sufficient habitat to support sustained natural production; the presence of a large in-basin hatchery release program below the dam that uses out-of-basin broodstock (ICTRT 2007a); and only a few individual fish may still be present from the original White Salmon population. Functionally extirpated populations are those with so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

Table ES-1. ESA listed DPS/ESU in the White Salmon River

Species	ESU/DPS	Status	Federal Register Notice	
Chinook salmon (*Oncorhynchus tshawytscha*)	LCR Chinook salmon	Threatened	70 FR 37160	6/28/2005
Coho salmon (*O. kisutch*)	LCR coho salmon	Threatened	70 FR 37160	6/28/2005
Chum salmon (*O. keta*)	CR chum salmon	Threatened	70 FR 37160	6/28/2005
Steelhead (*O. mykiss*)	MCR steelhead	Threatened	71 FR 834	1/5/2006
Critical Habitat Designation	LCR Chinook salmon, CR chum salmon, LCR coho salmon, MCR steelhead		70 FR 52630	9/2/2005

Context of Plan Development

This recovery plan provides direction for potential recovery of the White Salmon River's historical salmon and steelhead populations. This plan builds on the past and current efforts of the many parties currently working to rebuild populations and improve their habitat. This approach reflects NMFS's belief that it is critically important to base ESA (4f) recovery plans on the many state, regional, tribal, local, and private conservation efforts that are already underway. NMFS initiated a process that incorporated input from the Yakama Nation (YN), Washington Department of Fish and Wildlife (WDFW), Klickitat County, the Washington State Governor's Salmon Recovery Office, other Federal and state agencies, local governments, and the public. That process produced the White Salmon Recovery Plan.

Currently, there are 18 ESA-listed species of Pacific salmon and steelhead in the Pacific Northwest. For the purpose of recovery planning for these species, NMFS Northwest Region

designated five geographically based "recovery domains": Interior Columbia, Willamette/lower Columbia, Puget Sound and Washington Coast, Oregon Coast and the Southern Oregon/Northern California Coast. The White Salmon watershed is in an area where the Interior Columbia and Willamette/lower Columbia recovery domains overlap.

In each domain, NMFS has worked with state, tribal, and local entities and other Federal entities to develop planning forums that build to the extent possible on ongoing, locally led recovery efforts. NMFS defined "Management Units" based on jurisdictional boundaries as well as areas where local planning efforts were underway. In the LCR there are three management units for the LCR ESUs, these are 1) Oregon; 2) Washington; 3) the White Salmon River ESUs (not including the Steelhead DPS). In the MCR steelhead recovery domain the management units are 1) Oregon; 2) Washington Gorge, which, in turn, NMFS subdivided into three planning areas, White Salmon, Klickitat, and Rock Creek; 3) Yakima Basin; 4) Southeast Washington.

NMFS intends to incorporate the White Salmon Watershed Recovery Plan as an appendix to both the LCR Salmon and Steelhead Recovery Plan and the MCR Steelhead Recovery Plans since the White Salmon River watershed has ESA-listed species in both of the two NMFS Recovery Domains.

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each TRT was to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. The Willamette/lower Columbia Technical Recovery Team (W/LC TRT) provided technical support for the LCR ESUs recovery plan, while the Interior Columbia Technical Recovery Team (ICTRT), provided technical support for the White Salmon Steelhead Recovery Plan. These TRTs included biologists from NMFS, states, tribal entities, and academic institutions.

All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population viability criteria-criteria to be used, along with criteria based on mitigation of the factors for decline, to determine whether a species has recovered sufficiently to be downlisted or delisted. A NMFS technical memorandum, *Viable Salmon Populations and the Recovery of Evolutionarily Significant Units* describes these principles (McElhany et al. 2000). The memorandum defines VSPs in terms of four parameters: abundance, population productivity or growth rate, population spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework and based on data availability, the unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs are working from a common scientific foundation.

Physical Setting

The White Salmon watershed drains approximately 386 square miles in south central Washington (Figure ES-1). The river begins along the south slope of Mt. Adams and flows south 45 miles to enter the CR at Underwood, Washington at river-mile (RM) 168.3. White Salmon River salmon populations pass one mainstem CR dam, Bonneville Dam, during their migration to and from the Pacific Ocean.

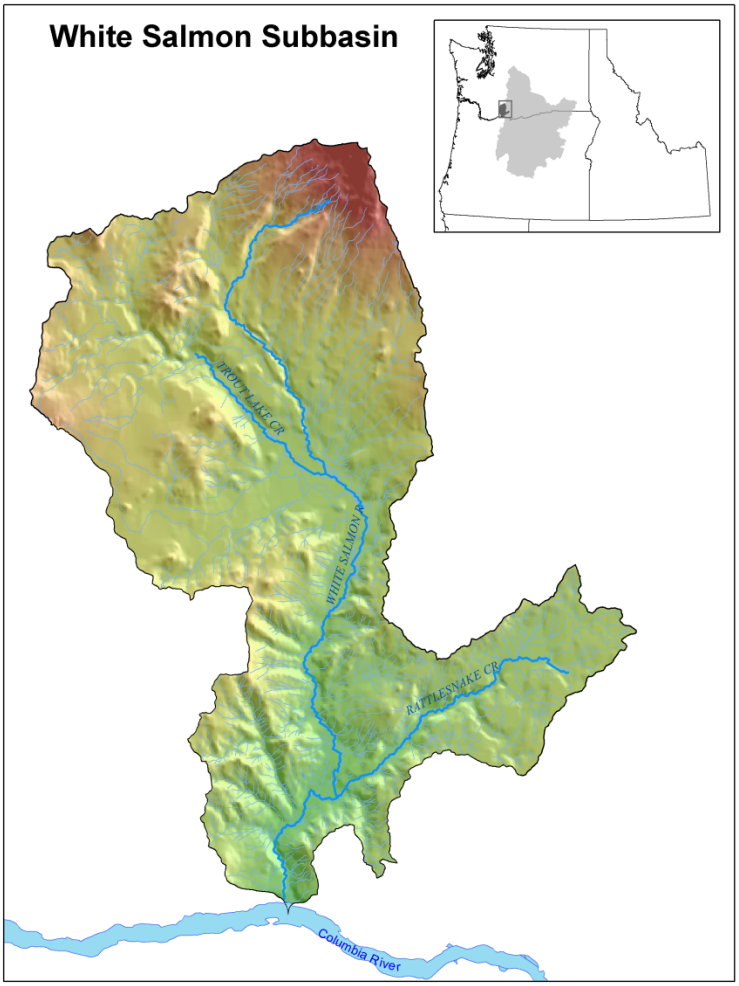


Figure ES-1. White Salmon watershed in Washington State (NPCC 2004)

Salmon and steelhead production in the White Salmon River watershed dropped significantly in the early 1900s after construction of Condit Dam at RM 3.3 on the White Salmon River. Condit Dam's original owners built a fish ladder; however, high flows twice destroyed the ladder and subsequent owners did not reconstruct it after 1919.

Fish passage, either through removal of the dam or installation of upstream and downstream fish passage facilities has been under evaluation as part of the Federal Energy Regulatory Commission (FERC) re-licensing process. PacifiCorp Power, the owner of Condit Dam,

rejected the proposal to install fish passage facilities and is currently removing the dam. This Plan includes a proposal to establish or re-establish natural production of salmon and steelhead in the White Salmon watershed, based on natural re-colonization of the habitat above the dam after removal. Recovery actions may also include implementation of hatchery augmentation of populations and/or hatchery preservation of genetic stocks.

The White Salmon watershed is part of both of Washington State's LCR salmon recovery domain and the MCR Steelhead Recovery sub-domain. White Salmon River is within parts of Skamania, Yakima, and Klickitat counties. In addition, the watershed falls within the state's Water Resource Inventory Area (WRIA) 29b. Half of the watershed lies within the Gifford Pinchot National Forest and supports timber production and recreational uses.

The White Salmon watershed contains lands the YN ceded to the United States in the Treaty of June 9, 1855. Within this area, the Tribe reserves the right "to hunt and fish at all usual and accustomed places." An in-lieu fishing site is located at the mouth of the White Salmon River, allowing tribal fishers to launch boats in an enclosed area and move out into the C R to their usual and accustomed fishing grounds.

Ecosystem Conditions

Condit Dam, at RM 3.3 on the mainstem White Salmon River, blocked all anadromous fish migration to historical habitats in the upper drainage. Dam removal began on October 26, 2011. Historical operations at Condit Dam altered flows in the lower White Salmon River, causing flows to drop to as low as 15 cubic feet per second (cfs) in the 1.1-mile bypass reach. Average natural flows are about 700 cfs. Power peaking at the dam affected the river system, causing diel flow variations and impairing watershed processes, such as the transportation of spawning gravels and Large Woody Debris (LWD) to areas downstream of the project (NPCC 2004). The lack of sediment transport into these reaches has affected habitat conditions downstream of Condit Dam. Conditions in the lower river below the former location of Condit Dam and under the former reservoir are anticipated to change substantially in response to the removal of the dam and subsequent stabilization actions.

Upstream of Condit Dam, the White Salmon River has a relatively constant natural flow pattern because of glacial melt and a large water storage capacity. Tributary stream flows drop to low levels in the summer and peak in the winter. Upstream of the dam, Northwestern Lake occupied the portion of the river between Buck Creek and the dam. Removal of the dam is exposing the lakebed. The coarseness of substrate sediment in the former lakebed is variable, with coarser material deposited at the top of the former reservoir and finer material downstream. Riparian vegetation is currently non-existent, and banks will be unstable until restoration actions are completed.

The extent of time it will take to re-establish channel and watershed processes in the former lakebed and the area below the former dam is unknown. Upstream of the former Northwestern Lake, some tributaries have warm water temperature, sparse riparian vegetation, high nutrient levels, low instream LWD abundance, and poor pool volume and frequency. Biologists have documented fish-borne diseases, Bacteria Kidney Disease (BKD) and Black Spot in the watershed (section 5.6, Predation, Competition and Disease).

Populations and Major Population Groups

Historically, MCR steelhead, likely ranged up the White Salmon River to the falls at RM 16 and into Buck, Spring, Indian, and Rattlesnake creeks (NPCC 2004). Based on accessible spawning habitat and a combination of notes, diary logs, and interviews (Lane and Lane Associates 1981), biologists assume that spring Chinook salmon and coho salmon were present historically in the watershed. Husum Falls, RM 7.6, may have blocked fall Chinook salmon migration and created a partial barrier for steelhead and coho salmon (NPCC 2004). All anadromous fish passage to historical habitats in the White Salmon drainage above RM 3.3 ended after construction of Condit Dam and the failure of the fish ladder in 1919. Now that Condit Dam has been removed, populations are anticipated to repopulate the watershed.

Presently, the historical spring Chinook salmon population is considered extirpated (Good et al. 2005; Myers et al. 2006), the historical steelhead population is considered functionally extirpated (ICTRT 2007b), the historical coho salmon population is considered extinct (Good et al. 2005; Myers et al. 2006), and the historical fall Chinook salmon population is considered at very high risk of extinction (ICTRT 2006; McElhany et al. 2004; Ford et al. 2011).

Biological Viability Criteria

White Salmon River fall Chinook salmon

The W/LC TRT gave the White Salmon River fall Chinook salmon population a weighted average extinction risk score of 0.86 on a scale of 0 to 4, with 0 = extirpation or nearly so, and 4 = very low extinction risk. This suggests that the population is at a very high risk of extinction (McElhany et al. 2004). Most W/LC TRT members considered hatchery strays to heavily influence the in-river fall-run Chinook salmon population, although some team members included the Spring Creek National Fish Hatchery (NFH) in their diversity evaluation as a potential source for re-establishing a native-run.

White Salmon River spring Chinook salmon

The W/LC TRT rated the White Salmon River spring-run Chinook salmon with a weighted average extinction risk score of 0.07, indicating the population is likely extirpated. The team concluded that any population that may have been historically present is currently extirpated because of construction of Condit Dam.

White Salmon River coho salmon

McElhany et al. weighted the White Salmon coho salmon population with an average extinction risk score of 0.39, indicating that the population is likely very near extinction (2004) or extinct (Good et al. 2005).

White Salmon River chum salmon

The lower Columbia Fish Recovery Board (LCFRB) identified the entire population of upper Gorge Chum salmon, which includes the historical population of chum salmon spawning in the White Salmon River, to have a very low viability (LCFRB 2004). Bonneville Reservoir inundates most of historical habitat for this population. T

White Salmon River steelhead

The ICTRT classified the White Salmon River steelhead population as functionally extirpated (ICTRT 2008). The ICTRT considers extirpated populations as those entirely cut off from anadromy. Functionally extirpated populations are those with so few remaining that there are not enough fish or habitat in suitable condition to support a fully functional population. The ICTRT identified one historical Major Spawning Area (MaSA) within the White Salmon watershed. A few individuals from the original population may have been spawning in the reach below Condit Dam and some evidence suggests that resident *O. mykiss* may have retained anadromous potential (Allen et al. 2006a and 2006b; Allen, personal communication, 2008).

Limiting Factors

Chapter 5 discusses in-watershed and out-of-watershed factors and related threats influencing the viability of the White Salmon River salmon and steelhead populations. NMFS defines limiting factors as the biological and physical conditions that limit a species' viability - e.g., high water temperature and defines threats as those human activities or naturally induced actions that cause the limiting factors. For example, removing the vegetation along the banks of a stream (the threat) can cause higher water temperatures (the limiting factor), because the stream is no longer shaded. Analysis of limiting factors and threats across the species' entire life cycle forms the basis for designing recovery strategies and actions.

"Threats" are present or likely anthropogenic activities or natural events that cause or contribute to the factors limiting the species' recovery. The development of threat reduction strategies can be complex, especially when human activities that pose threats to the species satisfy otherwise "beneficial" societal or cultural functions (e.g., flow management may threaten the species by reducing summer flows an increasing water temperatures, but the flow management may support an agricultural economy or protect human safety and property through flood prevention). In such circumstances, it is desirable to manage a threat in such a way that it minimizes or eliminates the negative impacts to the species, while retaining essential societal or cultural functions.

Blocked Passage

Until recently, blockage of fish passage upstream of Condit Dam was the single greatest factor limiting salmon abundance and productivity in the White Salmon River watershed. When the dam was in place, fall Chinook salmon accessed only a small percentage of their historical spawning and rearing habitat in the watershed. While the area directly below the dam was not "blocked," the hydraulics and substrate composition of this habitat had changed rendering it unsuitable for spawning. With the removal of Condit Dam, the hydraulics and substrate composition is evolving and now can support natural spawning though the habitat and substrates directly influence by the Bonneville Dam pool continue to limit spawning. Bonneville Dam has also flooded 80 percent of the spawning area used by chum salmon (NPCC 2004).

Tributary Habitat

The upstream habitats are currently being re-occupied by anadromous fish now that access has been provided. Spawning and rearing habitat upstream of the dam may eventually limit anadromous salmonid population abundance in the White Salmon River. Opportunities exist to improve upstream habitats to support future population levels. Sections 5.2, Freshwater Habitat and 6.2, Freshwater Habitat Strategies and Actions, for further discussion on tributary habitat.

Hatchery Practices and Releases

Chinook salmon

Most of the fish spawning naturally in the White Salmon River were assumed to be hatchery-origin tule fall Chinook salmon based on CWT recoveries. Spring Creek NFH began marking all of its hatchery production in 2004 and as a result, recent spawning ground surveys have shown that the majority of the tule fall Chinook salmon returning to the White Salmon River are of natural origin (Roler 2011). Spring Creek NFH tule fall Chinook salmon were originally derived from White Salmon tule fall Chinook salmon and are anticipated to contribute to natural production now that Condit Dam has been removed. Stray upriver bright (URB) hatchery fall Chinook salmon may adversely affect productivity of the tule fall Chinook salmon in the White Salmon River. These hatchery-origin strays are from releases at the Little White Salmon (LWS) NFH, located 3 miles downstream from the White Salmon River, and other releases in and below the Bonneville Pool. No facility releases hatchery-produced Chinook salmon into the White Salmon River watershed.

Coho salmon

Biologists found coho salmon from past releases by the LWS NFH to stray into the White Salmon watershed. Coho salmon releases from LWS NFH ended in 2004. Biologists consider these strays along with releases from other upstream Columbia Basin hatchery programs as the source of naturally spawning coho salmon in the White Salmon River.

Chum salmon

There are no hatchery chum salmon programs releasing fish above Bonneville Dam, although some incubated at the Washougal Hatchery and released as fry into Duncan Creek may be among those that ascend the Bonneville ladders.

Steelhead

Releases of Skamania stock winter steelhead and summer steelhead may limit the diversity of any naturally produced winter steelhead in the watershed. Scientists consider neither as part of the LCR or MCR steelhead DPSs. Fisheries managers terminated the releases of Skamania stock hatchery steelhead in 2010 in anticipation of breaching Condit Dam.

Harvest

Harvest currently does not limit the abundance or diversity of White Salmon River populations of steelhead, spring Chinook salmon, coho or chum salmon. All of these populations are extirpated or functionally extirpated (Good et al. 2005; ICTRT 2007b). Any

coho salmon, chum salmon, steelhead, and spring Chinook salmon found in the White Salmon River are strays from other basins. To protect naturally produced coho salmon, spring Chinook salmon, fall Chinook salmon, and steelhead in the White Salmon River, sport fisheries may only retain hatchery fish that are adipose fin-clipped and release all unmarked salmon and steelhead https://fortress.wa.gov/dfw/erules/efishrules/ (accessed January 3, 2013). Ocean and mainstem fisheries heavily harvest fall Chinook salmon, and harvest rates are likely to affect the rate of population growth once additional habitat in the watershed becomes available (section 5.4, Harvest, for further discussion).

Federal Columbia River Hydrosystem

Much of the mainstem Columbia and Snake rivers' current conditions are altered compared to historic conditions. The development of hydropower and water storage projects within the CR Basin have resulted in the inundation of many mainstem spawning and shallow-water rearing areas (e.g., loss of spawning gravels and access to spawning and rearing areas); altered water quality (e.g., reduced spring turbidity levels), water quantity (e.g., seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), water temperature (e.g., including generally warmer minimum winter temperatures and warmer maximum summer temperatures), water velocity (e.g., reduced spring flows and increased cross-sectional areas of the river channel), food (e.g., alteration of food webs, including the type and availability of prey species), and safe passage (e.g., increased mortality rates of migrating juveniles and steelhead kelts) (Williams et. al 2005; Ferguson et. al 2005).

Model studies indicate that the hydrosystem has decreased the delivery of suspended particulate matter to the LCR and estuary by about 40 percent (as measured at Vancouver, Washington) and has reduced fine sediment transport by 50 percent or more (Bottom et al. 2005). Overbank flow events, important to habitat diversity, have become rare, in part because flow management and irrigation withdrawals prevent high flows and in part because diking and revetments have increased the "bankfull" flow level (from about 18,000 to 24,000 m3/s). The dynamics of estuarine habitat have changed in other ways relative to flow. With increasing flow, the availability of shallow (between 10 cm and 2 m depth), low-velocity (less than 30 cm/s) habitat now appears to decrease at a steeper rate than during the 1880s, and the flow absorption capacity of the estuary appears to have declined.

The CR Estuary Module, at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm (accessed April 11, 2012) provides more information on factors that may limit viability of anadromous salmonids in the CR Estuary.

Predation, Competition and Disease

Because of Bonneville Dam's reservoir habitat, the abundance of predatory native and exotic fishes in the lower river has increased. Primary predators of juvenile salmonids in the CR include northern pikeminnow, smallmouth bass, and walleye. Terns, cormorants, and sea lions also consume large numbers of salmonids.

Hatchery steelhead juvenile releases into the White Salmon River probably led to competition with any natural origin smolts produced below the former Condit Dam, but hatchery managers have terminated these releases. Hatchery adults that stray into the White

Salmon River may compete for spawning and rearing habitat. Spawning of later returning URB fall Chinook salmon can reduce the productivity of naturally spawning tule fall Chinook salmon through redd superimposition.

Researchers have reported BKD and Black Spot throughout the White Salmon watershed (Allen et al. 2006a, 2006b). Now that Condit Dam has been removed, diseased fish may introduce other pathogens and diseases into the watershed. The effects of disease on current or any potential future populations are unknown.

Ocean Conditions

The effects of ocean conditions on abundance of Pacific salmon and steelhead vary among species and populations within species. Migration patterns in the ocean may differ dramatically and expose different stocks to different conditions in different parts of the ocean. Ocean survival of salmonids has been dramatically affected by widespread changes in ocean conditions; smolt-to-adult survival rates generally vary 10-fold between good and bad years.

Climate Change

Climate change represents a potentially significant threat to recovery of White Salmon River salmon and steelhead populations. Changes in climate may adversely affect salmon and steelhead by exacerbating existing problems with water quantity (e.g., lower summer stream flow) and water quality (e.g., higher summer water temperatures) and could be detrimental to many populations of salmonids and native fish species throughout the CR Basin. Changing conditions could also affect salmonid health and survival in the ocean through a variety of mechanisms, including increased ocean temperatures, increased stratification of some waters, changes in the upwelling season, shifts in the distribution of salmonids, long-term variability in winds and ocean temperatures, increased acidity, and increased atmospheric and oceanic variability (NMFS 2008a, Supplemental Comprehensive Analysis Chapter 5), available at http://www.nwr.noaa.gov/Salmon-Hydropower/Columbia-Snake-Basin/upload/Final_SCA_Ch1_7.pdf (accessed April 11,2012). See also ISAB 2007.

Recovery Goals and Criteria

The primary goal of this plan is to restore White Salmon River salmon and steelhead populations to viable status. McElhany et al. (2000) defines a VSP as an independent population that has negligible risk of extinction over a 100-year timeframe.

The visions, goals, and actions of many of the parties involved in the White Salmon recovery planning process may go beyond ESA delisting. These visions for broad-sense recovery incorporate ESA delisting goals. During the process of achieving broad-sense recovery goals, NMFS could delist White Salmon River salmon and steelhead. Broad-sense recovery goals incorporate many local and traditional uses, including those associated with rural and Native American values, which are important in the Pacific Northwest.

Biological Viability Criteria

One of the main tasks assigned to the TRTs was to develop biologically based criteria for ESA-listed salmon and steelhead. Viability criteria identify characteristics and conditions that, when met, would describe viable populations and a viable ESU or DPS.

The TRTs based their approaches to recovery on guidance from the NMFS Technical Memorandum *Viable Salmonid Populations and the Recovery of Evolutionarily Significant* Units (McElhany et al. 2000). This memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels. In their VSP guidelines, McElhany et al. (2000) recommend that a viable DPS population should be large enough to:

- Have a high probability of surviving variation observed in the past and expected future
- Be resilient to environmental and anthropogenic disturbances
- Maintain genetic diversity
- Support/provide ecosystem functions

NMFS organized the viability guidelines provided by McElhany et al. (2000) around four major considerations: abundance, productivity, spatial structure, and diversity. ESU-level viability criteria consider the appropriate distribution and characteristics of component populations to maintain the ESU/DPS in the face of longer-term ecological and evolutionary processes (ICTRT 2005a). NMFS adopted the ICTRT and W/LC TRT-defined viability criteria as the biological criteria for delisting of the ESUs and DPS that include the listed White Salmon populations discussed in this Plan.

Recovery Strategy and Actions

Chapter 6 describes the recovery strategies for the White Salmon River salmon and steelhead populations. The recovery strategies for each population contain three key components: 1) reintroducing naturally produced salmon and steelhead into historical habitat upstream of the former Condit Dam, 2) improving and increasing habitat for salmon and steelhead production downstream of Buck Creek, 3) improving habitat upstream of Buck Creek in anticipation of the growth of anadromous populations. The Plan also recommends that harvest or hatchery actions do not impede efforts to improve salmon and steelhead viability.

Table ES-2 lists the strategies and actions proposed as an integrated approach to address limiting factors and threats to salmon and steelhead and achieve broad-sense goals in four categories: freshwater habitat, hatcheries, harvest, and hydrosystem operations.

The Plan also proposes a number of actions focused on data gathering and analysis. These efforts are needed to monitor the current population status and habitat conditions and to improve the likelihood that efforts to reintroduce salmon and steelhead in the White Salmon are efficient and successful.

Together, NMFS expects the proposed strategies and actions to increase abundance, productivity, spatial structure, and diversity of White Salmon River salmon and steelhead.

The strategies and actions build from past and current efforts to restore passage and improve habitat conditions in the watershed.

Introduction/Restoration of Anadromous Salmonid Populations

In anticipation of the removal of Condit Dam, the White Salmon Working Group, made up of Federal, state, and tribal fisheries managers, as well as representatives of PacifiCorp (Condit Dam operators), developed several options for the reintroduction of salmon and steelhead into the White Salmon River. The group fleshed out each option with a description of the biological basis for the approach, operational and maintenance needs, and monitoring and evaluation needs. For details about the options and considerations, see Appendix I.

Fall Chinook salmon Reintroduction Plan Options

1. Salvage adipose-fin present Coded-Wire-Tag (CWT) - negative tule fall Chinook salmon from the White Salmon River in the fall of 2010 to start tule fall Chinook salmon restoration.
2. The Spring Creek NFH would spawn adults and rear eggs. The hatchery would acclimate and release the resulting juveniles at White Salmon Ponds.
3. No salvage effort in the White Salmon River or at Spring Creek NFH.
4. Salvage adipose-fin present CWT - negative tule fall Chinook salmon returning to the White Salmon River and outplant above Condit Dam prior to removal.

The White Salmon Working Group recommended the outplant Option 4 because they believed habitat is currently available above Condit Dam that can support natural spawning tule fall Chinook salmon. The White Salmon Working Group completed the salvage of native fish in late summer and early fall of 2011 prior to breaching the dam.

Spring Chinook salmon Reintroduction Plan Options

1. Natural colonization, i.e. no reintroduction efforts from outside sources.
2. Wild Klickitat spring Chinook salmon as brood source for juvenile release into the White Salmon River. Eggs collected and reared at Klickitat Hatchery, juveniles acclimated and released at White Salmon Ponds.
3. Klickitat Hatchery spring Chinook salmon as brood source for juvenile releases into upper White Salmon River (from Klickitat Hatchery thinning release or other surplus juveniles).
4. Klickitat Hatchery integrated stock spring Chinook salmon as brood source for juvenile release into White Salmon River, in future years (broodstock source would be hatchery-reared offspring of wild fish).
5. Transport surplus Klickitat Hatchery adults to White Salmon River.
6. Trap and transport Klickitat wild adults to White Salmon River.
7. Monitor natural escapement and production for 4-5 years then evaluate need and suitability of Option 4.

The White Salmon Working Group recommended Option 7. Under this option Working Group members propose to monitor escapement of spring Chinook salmon into the upper White Salmon River, including the proportion of Carson stock hatchery spring Chinook salmon on the spawning grounds. The White Salmon Working Group will also monitor spring Chinook salmon smolt production in the upper White Salmon. The 4-5 year monitoring period will determine if natural production is occurring and the source of that production. The monitoring period will also allow time for the development of the Klickitat Hatchery integrated spring Chinook salmon program and determine whether production capacity at this facility is available. The White Salmon Working Group considered the Klickitat Hatchery spring Chinook salmon program the best source of broodstock for reintroduction, even though it is not part of the LCR Chinook salmon ESU. The two nearest populations of spring Chinook salmon within the LCR ESU are in the Lewis River in Washington and the Sandy River in Oregon. Each of these basins have spring Chinook salmon hatchery programs, but reintroduction efforts in the Lewis River Basin require current local production in the Lewis River is needed for reintroduction efforts in that basin, while broodstock collection and funding shortfalls constrain production in the Sandy River. The result is the unavailability of a suitable source of LCR spring Chinook salmon to support the reintroduction efforts in the White Salmon River.

Coho salmon Reintroduction Plan Options

1. Natural re-colonization, i.e., no reintroduction efforts from outside sources.
2. Juveniles from Washougal and/or Bonneville/Cascade hatcheries released into White Salmon River.
3. Collection of wild adult broodstock in Klickitat River with spawning and rearing at hatchery facility and juvenile release in White Salmon River.
4. Collection of wild adult broodstock in White Salmon River with spawning and rearing at hatchery facility and juvenile release in White Salmon River.
5. Monitor natural escapement and production for 4-5 years then evaluate need and suitability of Options 2, 3, or 4.

The White Salmon Working Group decided on Option 5 for coho salmon. As described for spring Chinook salmon, White Salmon Working Group members propose to monitor escapement, hatchery- and natural-origin coho salmon on the spawning grounds, and juvenile production in the White Salmon River watershed. Sources of stray hatchery coho salmon include releases from Bonneville Hatchery and releases into the Klickitat and the Umatilla river basins. All of these releases derive from hatchery programs that are part of the LCR coho salmon ESU. A recovery team will use the results of the monitoring to determine future reintroduction activities.

Chum salmon Reintroduction Plan Options

1. Natural re-colonization, i.e., no reintroduction efforts from outside sources.
2. Active adult outplanting in years after Condit Dam removal.

3. Active stocking of juvenile chum salmon or outplanting of eggs in egg baskets and hatch boxes via WDFW's Washougal Hatchery or Willard NFH.

4. Initiate provisional hatchery program for chum salmon using existing US Fish and Wildlife Service (USFWS) hatcheries (White Salmon Ponds) for spawning and subsequent outplanting using chum salmon captured at Bonneville Dam.

The White Salmon Working Group decided on Option 1 for chum salmon. The group chose this option because of the uncertainty regarding the status of chum salmon above Bonneville Dam. This option calls for expanded spawning ground surveys in the Bonneville Pool using the mainstem chum salmon spawning habitat criteria developed for the population below Bonneville Dam. Those conducting surveys should focus in the lower reaches of suitable tributaries and include habitat suitability assessments for the reservoir and the tributaries.

Steelhead Reintroduction Plan Options

1. Natural re-colonization, i.e., no reintroduction efforts from outside sources.

2. Wild donor from local watershed as brood source for juvenile release into the White Salmon River. Eggs collected and reared at suitable hatchery, juveniles acclimated and released at White Salmon Ponds.

3. White Salmon resident *O. mykiss* as brood source, with locally suitable anadromous wild donor stock spawned for juvenile release into upper White Salmon River.

4. White Salmon steelhead captive brood program using captured outmigrating juveniles.

5. White Salmon steelhead kelt reconditioning. Recondition local spawners to enhance survival.

Based on the potential to re-establish natural production of steelhead in the watershed, the White Salmon Working Group decided Option 1, natural re-colonization, was the best approach. The indication that the (resident) population of *O. mykiss* in the White Salmon River above the former Condit Dam still produces smolts, even though the construction of Condit Dam and the end of passage in 1919 eliminated anadromy, was the basis of the group's decision. Recent monitoring in the White Salmon River above Condit Dam has identified *O. mykiss* juveniles displaying smolt behavior and morphology. Passive Integrated Transponder (PIT)-tagged juveniles have been detected passing Bonneville Dam, with one being recovered at the tern colony on East Sand Island (B. Allen personal communication, 2007). In addition, biologists detected an individual juvenile *O. mykiss* PIT-tagged above Condit Dam in September 2004 at 98 mm and again as an adult ascending Bonneville Dam in July 2006. Genetic analysis of juvenile *O. mykiss* collected in the upper watershed above Husum Falls found differences from hatchery trout released in the watershed; additional samples are needed, however, to confirm this finding (Allen et al. 2006a).

Additional research by Carmichael (Ruzycki et al. 2003) in the Grande Ronde and by Thrower et al. (2004) in Alaska supports the theory that even though the population is functionally extirpated, there is some potential for re-establishing anadromous steelhead in the White Salmon River watershed. Using resident *O. mykiss* above the former Condit Dam could provide a genetic link to historical anadromous *O. mykiss*.

Restoration of Habitat Impacted by Condit Dam and Formerly Occupied by Northwestern Lake

At the time this document was prepared, PacifiCorp had breached the dam and was in the process of removing the structure. PacifiCorp is currently implementing numerous decommissioning management plans that address protection of aquatic biota, bank stabilization, management of sediment and erosion, revegetation, and several other projects. The condition of the habitat downstream of the dam and that habitat recently occupied by the dam will be unknown for a period of time. A Research, Monitoring and Evaluation (RM&E) entity will complete an assessment of habitat conditions after the dam is fully removed and stabilization efforts are complete. Based on this information, a proposed Washington Gorge Management Unit entity will identify priority restoration actions. These will likely include riparian planting and bank stabilization, as well as other actions to be determined.

Habitat Improvement Upstream of Buck Creek in Anticipation of Future Population Growth

Biologists have completed, or are in the process of completing, assessments of current habitat condition in the upper watershed (particularly Rattlesnake Creek). Based on this information, the Plan identified actions that would improve habitat in the upper watershed in anticipation of eventual anadromous fish population growth and occupation of existing habitat. Actions include placement of LWD, planting and management of riparian areas, improvements in passage, reduction of sediment inputs, reduction of anthropogenic effects on stream flow, and other actions.

Table ES-2. Recovery Strategies and Actions for White Salmon River Salmon and Steelhead Populations

Action Type	Specific Action(s)
Dam Removal and Species Reintroductions	
Complete dam removal	Complete removal of Condit Dam
Restore channel, stabilize banks, replant banks, and restore habitat in inundated area previously occupied by the reservoir, as well as the habitats impacted downstream of the former Condit Dam site	Implement PacifiCorp's Decommissioning Management Plans
	Restore channel mainstream above the former Condit Dam
	Restore riparian condition
	Dredge mouth of White Salmon River if needed
Restore populations	Implement reintroduction plan for the White Salmon River salmonids
Post-Dam Removal RM&E	
Baseline habitat data collection	Gather information needed to identify and prioritize habitat actions that will provide the greatest opportunity to contribute to recovery
Population monitoring: - Monitor population abundance and productivity	Install & maintain large multiplexing PIT-tag detectors in the lower White Salmon mainstem and in Buck & lower Rattlesnake creeks. Report findings
  - Monitor proportion and origin of hatchery salmon and steelhead on the spawning grounds	Implement population monitoring in the White Salmon River & major anadromous-accessible tributaries.
	Install two small stationary instream PIT-tag detectors in the lower most portion of Spring Creek

Action Type	Specific Action(s)
- Assess the resident trout contribution to smolts downstream of the former Condit Dam; assess change in resident population after steelhead re-colonization/reintroduction	Pit-tag 3,000 juvenile salmonid each year upstream and downstream of the former Condit Dam to track individual movement and seasonal growth rates
	Conduct adult spawning ground surveys and monitor
	Create and maintain fish counts & biological database
	Mark adults for mark-recapture population estimates
	Derive estimates of salmonid population abundance & complete reporting
- Genetic analyses	Compare adult and smolt genetic analyses to ongoing adult salmon escapement estimates of WDFW and smolt outmigration estimates of United States Geographic Survey (USGS) studies in the White Salmon River
Habitat Restoration	
Protect and conserve existing natural ecological processes	Protect existing habitat from future degradation through land use planning
	Protect existing habitat from future degradation though land management plans, conservation easements, acquisitions, re-classification of lands as natural areas
Restore vegetation along stream sections that exceed state standards for temperature	Identify stream segments that are excessively warm; within those areas, work with willing landowners to implement actions to increase density of riparian vegetation where sparse; implement programs to protect existing riparian vegetation, reduce sediment inputs to streams
Restore passage and connectivity to habitats blocked or impaired by artificial barriers	In cooperation with irrigation district and others, remove or replace barriers inhibiting upstream passage including dikes, culverts, and irrigation structures, provide/upgrade screening of irrigation diversions
	Indian Creek culvert replacement
Reduce nutrient inputs	Reduce runoff of nutrients from septic tanks, dairies, agricultural lands, and other sources
Improve LWD abundance and recruitment	In cooperation with landowners plan, design and install stable wood and other large debris in streambeds and develop approaches to ensuring long-term LWD recruitment
	In cooperation with landowners develop grazing strategies that promote riparian recovery
Invasive species	Eradicate invasive plant species from riparian areas
Restore channel	With willing landowners, stabilize stream banks, restore natural channel form, reduce sediment inputs as needed from roads
Reduce anthropogenic effects on stream flow	Quantify anthropogenic effects on stream flow and identify priority actions
	With willing landowners, implement water conservation measures
	Improve irrigation conveyance and efficiency
	Employ Best Management Practices (BMP)s with willing landowners
	Protect/restore springs with willing landowners
	Increase pool habitat
	Restore wetlands with willing landowners
	Hydrologically disconnect roads from streams

Action Type	Specific Action(s)
	Control road/stream interactions by reducing erosion potential
Public awareness	Public awareness regarding restoration projects and importance of wood in streams and riparian areas
Harvest	
Harvest management	Manage harvest for low impact fisheries and rapid anadromous fish population growth
	Adjust tributary harvest regulations in areas where harvest significantly impacts salmon and steelhead population growth
Hatcheries	
Reintroduction: Hatchery production	Rehabilitate White Salmon Ponds and update intake screen
Hydrosystem and Mainstem Predation	
Maintain or improve hydropower operations and facilities at Bonneville Dam to enhance salmon and steelhead survival	Decrease water travel time during smolt outmigration
Maintain or improve hydropower operations and facilities at Bonneville Dam to enhance salmon and steelhead survival	Improve operation of adult passage, maintain high standards of adult fish passage at Bonneville Dam
Reduce predation on salmonids	Reduce predation by pinnipeds, piscivores, cormorants and Caspian terns

Implementation and Cost Estimates

This plan provides specific management strategies and actions needed to address re-establishing viable anadromous salmonid populations in the White Salmon River watershed. These actions represent activities with the greatest potential for protecting and recovering salmon and steelhead, as well as for achieving broad-sense recovery goals. Implementation of recovery actions is not a one time or short-term initiative. The programs and actions will likely need sustaining, evaluating, adjusting, and augmenting over the full recovery period.

NMFS encourages the formation of a planning group for the Washington Gorge Management Unit, a forum or entity that would take responsibility for coordinating implementation of the White Salmon River Watershed Recovery Plan. Implementing the proposed recovery actions for MCR steelhead in the Washington Gorge Management Unit, which includes the White Salmon watershed, would be a primary task for a Washington Gorge Area Regional Board, subject to state, tribal, and local government concurrence and the opportunity for public involvement and comment.

Chapter 7 provides cost estimates developed by the Washington Gorge Implementation Team (WAGIT) for implementing the proposed habitat actions described in Chapter 6 for the White Salmon drainage. The Plan identified numerous RM&E actions. The results of studies will help to identify the priority actions within the watershed. The estimated RM&E actions will cost roughly $1,540,000 over a 5-year period. Implementation of PacifiCorp's decommissioning plans is estimated to cost $0.9 to $1.1 million. Additional actions could cost up to $15,100,000. The total cost over a 5-year period for restoring anadromous populations in the White Salmon River could be as much as $16,781,000. Funding is not yet available to cover $13,200,000 of this cost.

Monitoring, Research and Adaptive Management Framework

As part of implementing the White Salmon Recovery Plan, the proposed Washington Gorge Management Unit or another entity will design a detailed monitoring and evaluation program, which will be incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS guidance document, *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance* (available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm (accessed April 11, 2012).

The White Salmon monitoring and evaluation program will build on existing programs designed for monitoring tributary habitat in the White Salmon River. Additionally, the program will provide 1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed, 2) a plan for tracking such metrics and indicators, 3) a decision framework in which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the Plan's goals.

1 Introduction

The ESA of 1973 requires NOAA's NMFS to develop recovery plans for species listed under the Act. The purpose of recovery plans is to identify actions needed to restore threatened and endangered species to the point where they are again self-sustaining elements of their ecosystems and no longer need the protection of the ESA.

This is a plan for the recovery of White Salmon River populations of fall Chinook salmon and steelhead, and for establishing or re-establishing spring Chinook salmon, coho, and chum salmon populations in the White Salmon River so that they can contribute to the conservation and survival of the threatened LCR Chinook salmon, LCR coho salmon, and CR chum salmon ESUs, and the threatened MCR steelhead DPS.[2]

The White Salmon River drains approximately 386 square miles in southwestern Washington and joins the CR at Underwood, Washington, CR RM 163 (See Figure 1-1).

Salmon and steelhead production in the White Salmon River watershed dropped significantly in the early 1900s after construction of Condit Dam at RM 3.3 on the White Salmon River. Although the original owners constructed Condit Dam with a fish ladder, high flows twice destroyed the ladder, which was not rebuilt after 1919. The dam blocked access to most of the historical range of both spring and fall Chinook salmon, steelhead, and coho salmon populations that once spawned in the watershed. PacifiCorp breached Condit Dam in October 2011 and is currently removing the dam. This recovery plan includes the proposal developed as part of the FERC decommissioning process to re-establish natural production of spring and fall Chinook salmon, coho, chum salmon, and steelhead in the White Salmon watershed, based on natural re-colonization of the habitat above the dam after removal is complete. In addition, the Bonneville Dam reservoir inundated much of the historical spawning habitat of the chum salmon population that historically spawned in the watershed (NMFS 2005). Some salmon and steelhead currently spawn and rear in accessible habitat below Condit Dam.

The watershed's native salmon and steelhead populations are not viable and their respective ESUs/DPSs are now listed for protection under the ESA. The MCR steelhead population in the White Salmon River is considered functionally extirpated (ICTRT 2008) and also the LCR spring Chinook salmon and coho salmon and the CR chum salmon are considered extirpated (Myers et al. 2006).

[2] An 'evolutionarily significant unit' (ESU) of Pacific salmon (Waples 1991) and a 'distinct population segment' (DPS) of steelhead (71 FR 834, January 5, 2006) are considered to be 'species,' as defined in section 3 of the ESA.

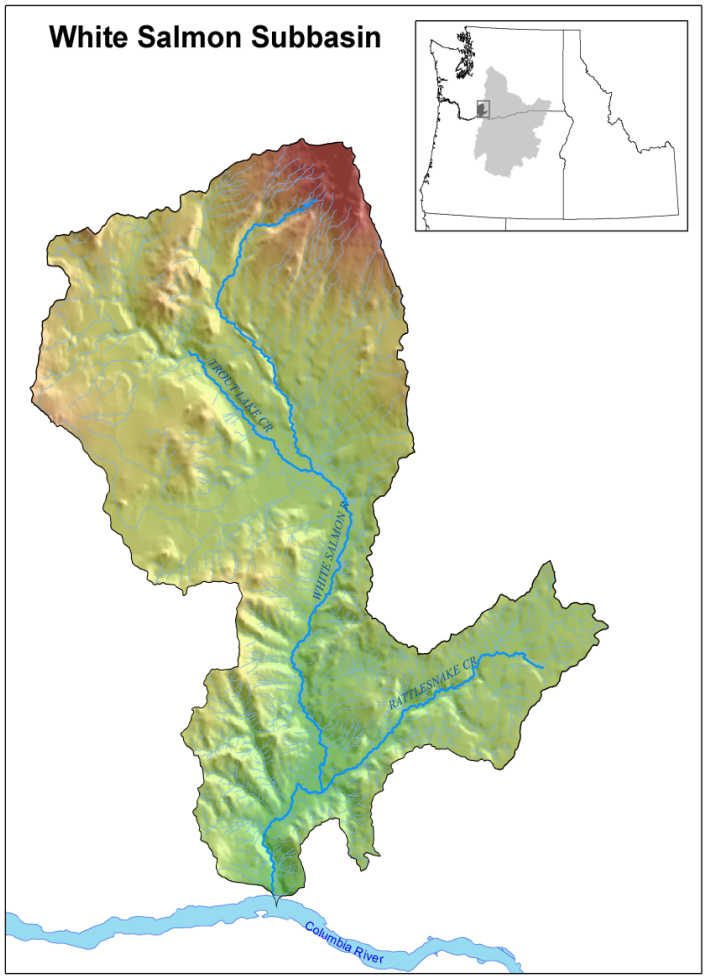


Figure 1-1. White Salmon watershed in Washington State

NMFS developed this recovery plan with participation and technical contributions from the YN, WDFW, Klickitat County, Washington State Governor's Salmon Recovery Office, other Federal and state agencies, local governments, and the public. While NMFS is the agency responsible for recovery planning for salmon and steelhead under the ESA, NMFS believes it is critically important to base ESA recovery plans for salmon and steelhead on the many state, regional, tribal, local, and private conservation efforts already underway throughout the region, and has attempted to do so in this plan.

1.1 Purpose of Plan

A recovery plan provides a roadmap for restoring a listed species or population to the point where it becomes a viable component of its ecosystem. Recovery plans are not regulatory; they are guidance for recovery efforts. This Plan describes the current status of the White Salmon River salmon and steelhead populations and their habitat in the White Salmon watershed. The Plan also identifies the major limiting factors and threats affecting the populations and proposes strategies and actions designed to aid in population recovery by building on past and current efforts. Finally, the Plan provides an implementation and

adaptive management framework for making needed future adjustments on the road to recovery.

1.1.1 ESA Requirements

Section 4(f) of the ESA requires that a recovery plan be developed and implemented for species listed as endangered or threatened under the statute. ESA section 4(a)(1) lists factors for re-classification or delisting, which are to be addressed in recovery plans:

a. Present or threatened destruction, modification, or curtailment of [the species'] habitat or range

b. Over-utilization for commercial, recreational, scientific, or educational purposes

c. Disease or predation

d. Inadequacy of existing regulatory mechanisms

e. Other natural or human made factors affecting its continued existence

ESA section 4(f)(1)(B) directs that recovery plans, to the extent practicable, incorporate:

a. Description of such site-specific management actions as may be necessary to achieve the Plan's goal for the conservation and survival of the species;

b. Objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this chapter, that the species be removed from the list;

c. Estimates of the time required and the cost to carry out those measures needed to achieve the Plan's goal and to achieve intermediate steps toward that goal.

Once a species is deemed recovered, and therefore removed from a listed status, section 4(g) of the ESA requires the monitoring of the species for not less than 5 years to ensure that it retains its recovered status.

1.1.2 Coordination with Others

This Plan has been developed to achieve consistency with other related planning and management efforts.

Federal Treaty and Trust Responsibilities

Northwest Indian Tribes have legally enforceable rights reserving to them a share of the salmon harvest. In the Treaties of 1855 between the U.S. Government and the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe, the tribes, in exchange for the preponderance of their lands, reserved the rights to fish within their reservations and "at all other usual and accustomed places." The usual and accustomed places are understood to include the millions of acres of aboriginal land ceded to the United States in the 1855 treaties, which extends to the upper Columbia and Snake River Basins, and includes most of the geographic range of the middle Columbia

steelhead DPS. A complex history of treaties, executive orders, legislation, and court decisions have culminated in the recognition of tribes as co-managers who share management responsibilities and rights for fisheries in the Columbia Basin.

Achieving the basic purpose of the ESA (to bring the species to the point that it no longer needs the protection of the Act) may not by itself fully meet these rights and expectations, although it will lead to major improvements in the current situation. Ensuring a sufficient abundance of salmon to sustain harvest is an important element in fulfilling trust and treaty rights as well as garnering public support for these plans. ESA and tribal trust responsibilities complement one another. Both depend on a steady upward trend toward ESA recovery and delisting in the near term, while making aquatic habitat, harvest, and land management improvements for the long-term.

It is appropriate for recovery plans to take these considerations into account and plan for a recovery strategy that includes harvest. In some cases, increases in the naturally spawning populations may be sufficient to support harvest. In others, the recovery strategy may include appropriate use of hatcheries to support a portion of the harvest. So long as the overall plan is likely to achieve the recovery of the listed ESU/DPS, it will be acceptable as a recovery plan.

The NMFS Regional Administrator, in testimony before the U.S. Senate Indian Affairs Committee (June 2003), emphasized the importance of this co-manager relationship: "We have repeatedly stressed to the region's leaders, tribal and non-tribal, the importance of our co-management and trust relationship to the tribes. NMFS enjoys a positive working relationship with our Pacific Northwest tribal partners. We view that relationship as crucial to the region's future success in recovery of listed salmon."

Treaty Indian fishing rights in the CR Basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *U.S. v. Oregon*, No. 68-513 (filed in 1968). The parties to *U.S. v. Oregon* are the United States acting through the Department of Interior (USFWS and Bureau of Indian Affairs (BIA)) and Department of Commerce (NMFS), the Warm Springs, Umatilla, Nez Perce, Yakama, and Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho. In *U.S. v. Oregon*, the Court affirmed that the treaties reserved for the tribes 50 percent of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas.

The White Salmon watershed contains lands ceded to the United States by the YN in the Treaty of June 9, 1855. Within this area, the Tribe reserves the right "to hunt and fish at all usual and accustomed places." An in-lieu fishing site is located in the White Salmon River upstream of the bridge at the mouth. This location allows tribal fishers to launch boats in an enclosed area and move out into the CR to their usual and accustomed fishing sites.

Several historical seasonal encampments and fishing areas used by local Indian bands were located on the White Salmon and its tributaries. Historically, before European settlement of the area, significant fisheries and winter village sites were located at the mouth of the White Salmon, at Husum Falls, RM 7.6 and at the falls at BZ Corner, RM 12.4. Another important winter village was located at Trout Creek (Lane and Lane Associates 1981). The Yakama people occupied the entire Rattlesnake Creek drainage. Villages were located near the confluence of the White Salmon River and Rattlesnake Creek, and another approximately

four miles up the creek. The upper White Salmon watershed also contains current and historical huckleberry fields traditionally used by the YN. Archaeological sites throughout the area testify to the importance of the White Salmon watershed as a seasonal and perennial area of aboriginal use. Present day tribal groups whose treaty reserved fisheries were affected by Condit Dam are the Confederated Tribes and Bands of the Yakama Indian Nation, Confederated Tribes of the Warm Springs Reservation of Oregon, Confederated Tribes of the Umatilla Reservation of Oregon, and the Nez Perce Tribe of Idaho (Lane and Lane Associates 1981).

Other Federal, State and Local Responsibilities

To ensure consistency in goals, strategies, and actions and to eliminate duplication of effort, planners and program administrators have endeavored to achieve consistency between ESA recovery plans, the Northwest Power and Conservation Council (NPCC) fish and wildlife program, the State of Washington watershed management and salmon recovery programs, and local planning and regulatory efforts.

This Recovery Plan builds upon the White Salmon Subbasin Plan (NPCC 2004), which was developed for the NPCC by the YN, WDFW, and other Federal, state, and local entities. The Plan contains an assessment and inventory of fish and wildlife resources in the watershed, as well as a management plan identifying locally informed fish and wildlife protection and restoration priorities. The NPCC adopted the White Salmon Subbasin Plan into its Fish and Wildlife program. Additional scientific data are drawn from other more recent sources, including technical products developed by TRTs appointed by NMFS for the Interior Columbia and Willamette/lower Columbia Willamette lower Columbia recovery domains and studies completed by the YN Fisheries, the U.S. Geological Survey (USGS), USFWS, and the Underwood Conservation District (UCD).

This Plan is the product of a process initiated by NMFS, involving technical input from the YN, WDFW, Klickitat County, the Washington State Governor's Salmon Recovery Office, LCFRB, other Federal agencies, state agencies, local governments, and the public. The Plan's recovery strategy for White Salmon River salmon and steelhead includes recommendations by these parties.

1.2 Context of Plan Development

Currently, there are 18 ESA-listed ESUs/DPSs of Pacific salmon and steelhead in the Pacific Northwest. For the purpose of recovery planning for these species, NMFS Northwest Region designated five geographically based "recovery domains": Interior Columbia; W/LC; Puget Sound and Washington Coast; the Oregon Coast; and the Southern Oregon/Northern California Coast.

The White Salmon watershed is in an area of overlap between the Interior Columbia and W/LC recovery domains. Columbia River Chinook salmon, coho, and chum salmon are included in the W/LC domain. A run of fall Chinook salmon continues to exist in the watershed. Chum, coho and spring Chinook salmon are considered extinct, extirpated, or functionally extirpated (Myers et al. 2006).

The range of the middle Columbia River Steelhead DPS includes the White Salmon River watershed. The White Salmon River steelhead population is considered functionally extirpated. The entire recovery plan for the White Salmon River population of Middle Columbia River steelhead was not included in the *Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan*. The Middle Columbia River plan explains that while the White Salmon watershed, which historically supported a population of Middle Columbia River steelhead, is part of the Washington Gorge management unit, the recovery plan for that population was being finalized as part of the *Lower Columbia ESA Recovery Plan*. The reason for including the White Salmon River population of Middle Columbia steelhead in the Lower Columbia ESA Recovery Plan was because the White Salmon River also includes single populations of three listed ESUs of salmon (Lower Columbia River Chinook and coho salmon and Columbia River chum). The need for an ecosystem approach warranted addressing all the listed salmonids that spawn in the White Salmon watershed in one plan. However, the delisting criteria, actions, and costs for the White Salmon River steelhead population are included in the Middle Columbia DPS plan in order to have all the information on the Middle Columbia steelhead DPS in one place. The Middle Columbia River steelhead DPS recovery plan will be updated to include the White Salmon Management Unit plan as an appendix. However, inclusion of the White Salmon Management Unit plan does not alter the recovery criteria articulated for the White Salmon River steelhead population in the Middle Columbia River steelhead DPS recovery plan.

Technical Recovery Teams (TRT)

For each domain, NMFS appointed a team of scientists, nominated for their geographic and species expertise, to provide a solid scientific foundation for recovery plans. The charge of each TRT was to define ESU/DPS structures, develop recommendations on biological viability criteria for each ESU or DPS and its component populations, provide scientific support to local and regional recovery planning efforts, and provide scientific evaluations of proposed recovery plans. Both the W/LC TRT and the ICTRT did work relevant to the White Salmon populations. Each TRT included scientists from NMFS, states, tribal entities, academic institutions, and other Federal agencies.

All the TRTs used the same biological principles for developing their recommendations for ESU/DPS and population level viability criteria-criteria to be used, along with criteria based on mitigation of the factors for decline, to determine whether a species has recovered sufficiently to be downlisted or delisted. These principles are described in a NMFS technical memorandum, *Viable Salmon Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). VSPs are defined in terms of four parameters: abundance, productivity or growth rate, spatial structure, and diversity. A viable ESU/DPS is naturally self-sustaining, with a high probability of persistence over a 100-year time period. Each TRT made recommendations using the VSP framework and based on data availability, the unique biological characteristics of the ESUs/DPSs and habitats in the domain, and the members' collective experience and expertise. Although NMFS has encouraged the TRTs to develop regionally specific approaches for evaluating viability and identifying factors limiting recovery, all the TRTs are working from a common scientific foundation.

1.2.1 Planning Forum

In each of the W/LC and Interior Columbia recovery domains, NMFS has worked with state, tribal, local, and other Federal entities to develop planning forums that build to the extent possible on ongoing, locally led recovery efforts. NMFS defined "Management Units" based on jurisdictional boundaries as well as areas where local planning efforts were underway. The W/LC Domain has four management units: 1) Oregon, 2) Washington, 3) White Salmon and 4) Upper Willamette. The middle Columbia, a sub-domain of the Interior Columbia, also has four management units: 1) Oregon; 2) Washington Gorge, which, in turn, is subdivided into three planning areas; White Salmon, Klickitat, and Rock Creek; 3) Yakima Basin; 4) Southeast Washington.

NMFS works with recovery planning forums developed by the State. In Washington State these forums typically include representatives from state, tribal, local governments, and other stakeholders. The appropriate jurisdictions have not yet established a planning forum for the Washington Gorge Management Unit. Therefore, NMFS has worked independently with the YN, Klickitat County, WDFW, and local entities to develop the recovery plan for White Salmon River salmon and steelhead populations. NMFS encourages creation of a local planning forum that could provide guidance for further development and implementation of recovery plans for the Washington Gorge Management Unit.

1.3 How NMFS Intends to Use the Plan

Although recovery plans are not regulatory and their implementation is voluntary, they are important tools that help to do the following:

- Provide context for regulatory decisions
- Guide decision making by Federal, state, tribal, and local jurisdictions
- Provide criteria for status reporting and delisting decisions
- Organize, prioritize, and sequence recovery actions
- Organize research, monitoring, and evaluation efforts

NMFS will encourage Federal agencies and non-Federal jurisdictions to take recovery plans under serious consideration as they make the following sorts of decisions and allocate their resources:

- Actions carried out to meet Federal ESA section 7(a)(1) obligations
- Actions that are subject to ESA sections 4d, 7(a)(2), or 10
- Hatchery and Genetic Management Plans and permit requests
- Harvest plans and permits
- Selection and prioritization of basin and watershed planning actions
- Development of research, monitoring, and evaluation programs
- Revision of land use and resource management plans

- Other natural resource decisions at the state, tribal, and local levels

NMFS will emphasize recovery plans in ESA section 7 (a)(2) consultations, section 10 permits, and application of the section 4(d) rule by considering:

- Delisting criteria that address both viability and threats
- Description of limiting factors and threats (factors for decline)
- Description of a recovery program (site specific management actions necessary to achieve recovery of the species)
- Estimates of the time and cost to carry out measures to achieve the Plans' goals

In implementing these programs, recovery plans will be used as a reference and a source of context, expectations, and goals. Under section 7 of the ESA, NMFS staff will encourage the Federal "action agencies" to describe in their biological assessments how their proposed actions will affect specific populations, the limiting factors identified in the recovery plans, and any mitigating measures and voluntary recovery activities in the action area.

2 Biological Background

This chapter describes population and habitat characteristics for the White Salmon River salmon and steelhead populations. The chapter also discusses hatchery production and releases and harvest management in the White Salmon River watershed.

2.1 Populations and Major Population Groups

Lower Columbia River Chinook salmon

White Salmon River fall and spring Chinook salmon are included in the LCR Chinook salmon (*Oncorhynchus tshawytscha*) ESU, which NMFS listed as threatened on March 24, 1999, and reaffirmed on June 28, 2005. The ESU includes all naturally spawned populations of Chinook salmon in the CR and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point east of Hood River in Oregon and the White Salmon River in Washington. The historical site of Celilo Falls on the CR is considered the transitional point for this ESU, since it may have been a migration barrier to Chinook salmon at certain times of year (Myers et al. 1998). The ESU exhibits three major life history types: fall-run (tules), late fall-run (brights), and spring-run. The White Salmon River historically supported two of these life history strategies: fall-run Chinook salmon tules (Figure 2-1), and spring-run Chinook salmon (Figure 2-2).

There is no direct documentation of a historical (pre-Condit Dam) population of naturally spawning spring Chinook salmon (Myers et al. 2006). Fulton (1968) speculated that tribal members historically caught Chinook salmon upstream of Husum Falls, which were likely spring Chinook salmon, citing Bryant (1949) and USFWS (1951). These reports, however, did not indicate direct observations. Evermann and Meek (1898) surveyed the White Salmon River in August and September. No Chinook salmon were observed in August, possibly due to conditions not being conducive to observation due to flooding from the CR and to investigating only the lower mile of the river. Additionally, LeMier and Smith (1955) interviewed a long time resident who was unable to confirm the presence of spring Chinook salmon in the watershed.

Even though documentation of direct observations of spring Chinook salmon by 20th-centery residents, Myers et al. 2006 determined, based on the historically available habitat, that spring Chinook salmon were historically present in the basin. The observation of a spring Chinook salmon redd above Husum Falls on September 20, 2012, further supports the historical presence of spring Chinook salmon in the basin (personal communication R. Engle, USFWS, 2012). The determination that the redd observed belonged to spring Chinook salmon was based on the timing of the redd (prior to tule fall Chinook salmon spawning), the size (too large for resident trout), and its location above Husum Falls (no fall Chinook salmon have been observed above Husum Falls).

LeMier and Smith (1955) evaluated the capacity of the White Salmon River to support salmon if passage was re-established. Under conditions existing in 1955, they estimated the river could support 732 spring Chinook salmon and 452 fall Chinook salmon, but noted that conditions in the White Salmon River were degraded substantially in 1955 relative to historical levels. Ecosystem Diagnosis and Treatment (EDT) modeling indicated the historic

potential abundance of fall Chinook salmon was roughly 775 adults. This figure is less than the estimated current potential without harvest, which suggests some error in the model assumptions or the reporting of results (Allen and Connolly 2005). The EDT modeling indicated the historic potential abundance of spring Chinook salmon was roughly 825 adults.

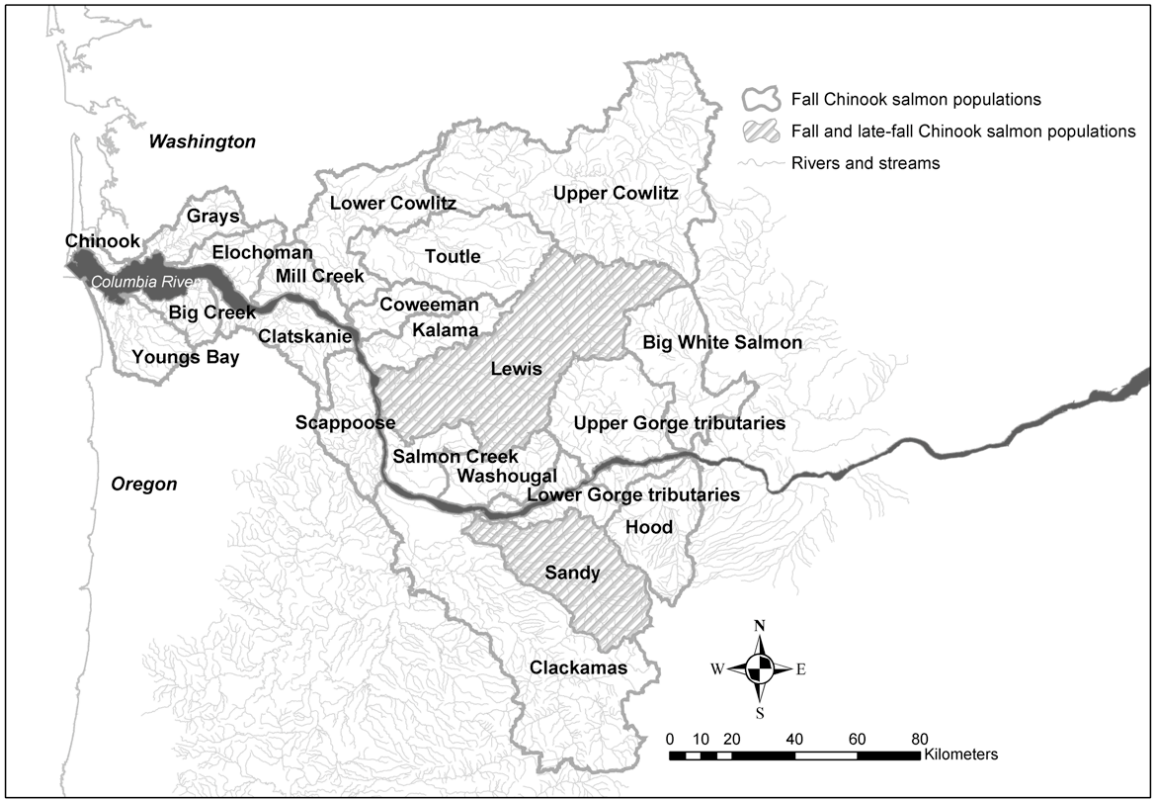


Figure 2-1. Historical fall and late fall demographically independent populations in the lower Columbia River Chinook salmon ESU (Myers et al. 2006)

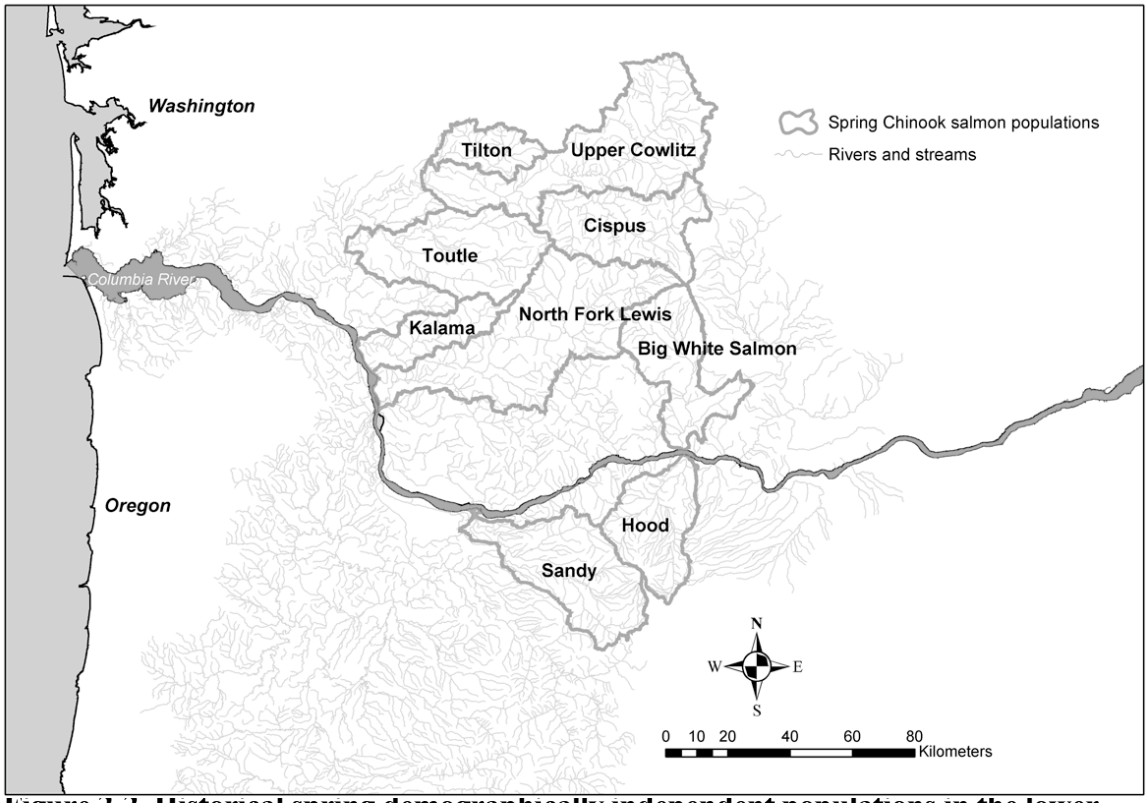


Figure 2-2. Historical spring demographically independent populations in the lower Columbia River Chinook salmon ESU (Myers et al. 2006)

Lower Columbia River coho salmon

White Salmon River coho salmon are part of the LCR coho salmon (*Oncorhynchus kisutch*) ESU, which NMFS listed as threatened on June 28, 2005. The ESU includes all naturally spawned coho salmon populations in the CR and its tributaries from the mouth of the CR to a transitional point east of the Hood River in Oregon and the White Salmon River in Washington (Figure 2-3). At the time of listing, biologists identified only two naturally spawning populations: the Sandy River and the Clackamas River populations in Oregon.

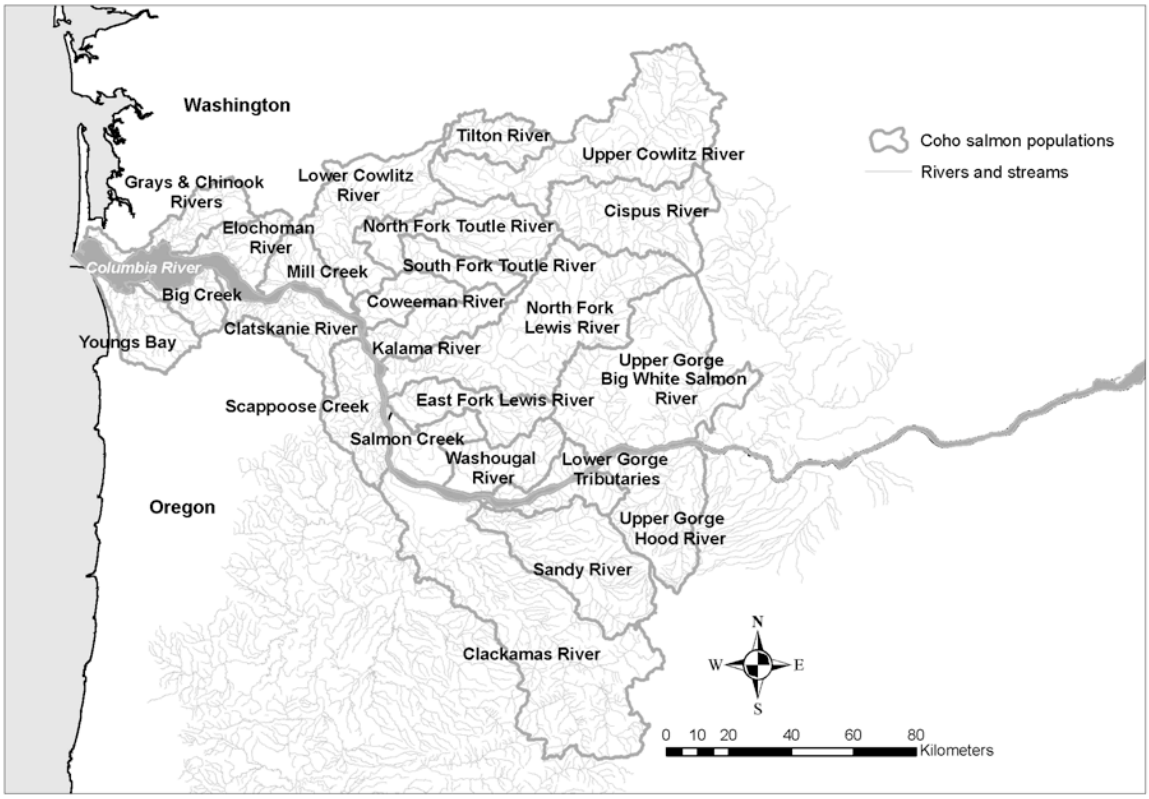


Figure 2-3. Historical demographically independent populations in the lower Columbia River Coho salmon ESU (Myers et al. 2006)

Columbia River chum salmon **-** White Salmon River chum salmon were part of the upper Gorge Tributaries population of CR chum salmon *(Oncorhynchus keta*) ESU, which NMFS listed as threatened on March 25, 1999, and reaffirmed on June 28, 2005. The ESU includes all naturally spawning populations in the CR and its tributaries in Washington and Oregon (Figure 2-4).

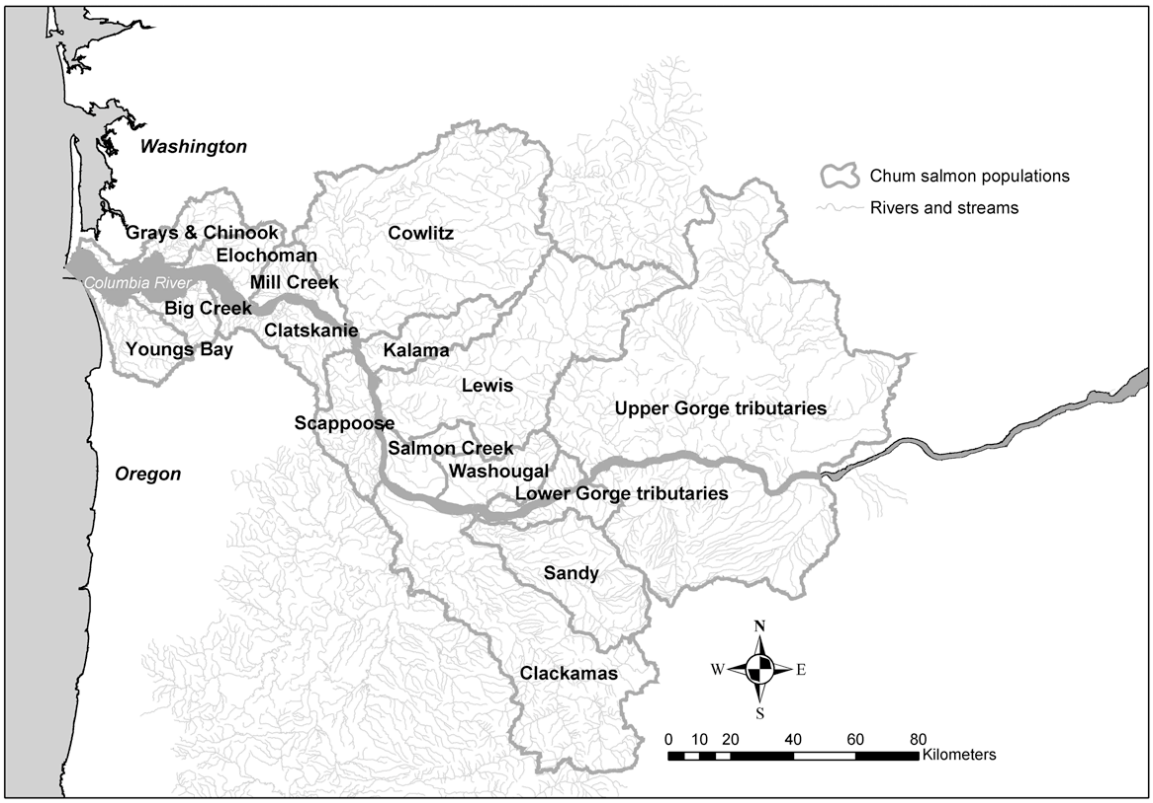


Figure 2-4. Historical demographically independent populations in the Columbia River chum salmon ESU (Meyers et al. 2006)

Middle Columbia River Steelhead

White Salmon River steelhead are part of the MCR Steelhead (*Oncorhynchus mykiss*) DPS, which NMFS listed as threatened on January 5, 2006. This DPS includes all naturally produced steelhead in the CR Basin upstream of the Wind River in Washington and the Hood River in Oregon (exclusive) to the Yakima River in Washington. Excluded are steelhead from the Snake River Basin (Busby et al. 1996). The MCR Steelhead DPS includes the only populations of inland winter steelhead in the United States (in the Klickitat and White Salmon rivers, Washington, and in Fifteenmile Creek, Oregon). The ICTRT identified 20 populations within the DPS (16 summer-run and 4 winter-run). In addition the ICTRT identified the historical populations that have been extirpated in Willow Creek due to dam construction in the Deschutes River Basin (ICTRT 2004). Figure 2-5 shows populations within the DPS. The White Salmon population was initially considered to be one of the extirpated populations, (however, later analysis defined the population as being functionally extirpated (ICTRT 2007b).

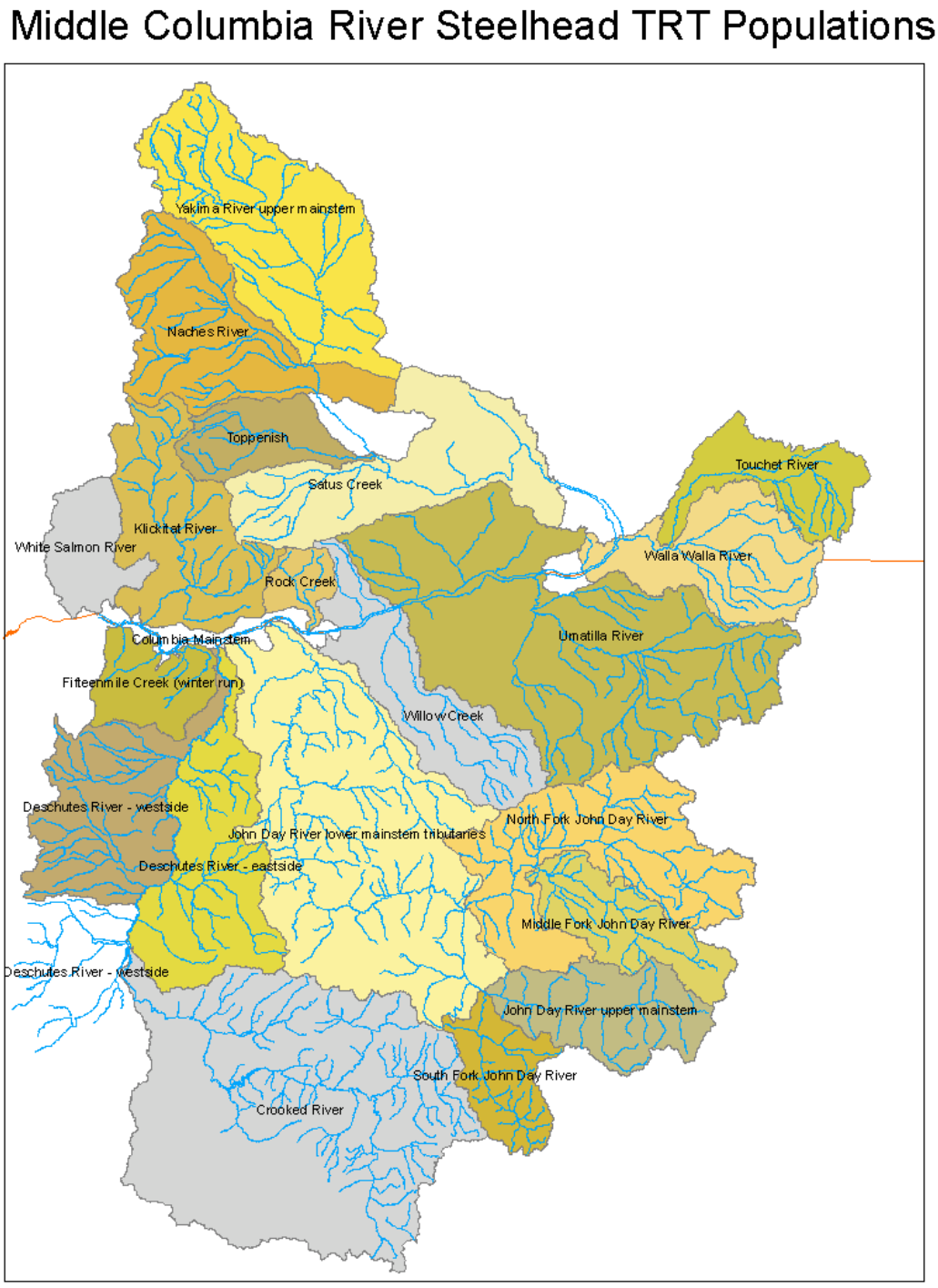


Figure 2-5. Historical summer and winter steelhead populations in the middle Columbia River DPS (ICTRT 2004; ICTRT 2007b). Note populations in gray are extirpated or functionally extirpated

2.2 Physical Setting

The White Salmon River watershed drains approximately 386 square miles in south central Washington. The river begins along the south slope of Mt. Adams and flows south 45 miles to enter the CR at Underwood, Washington at CR RM 168.3. Elevation in the watershed ranges from 12,307 feet on Mt. Adams to 72 feet at the river's mouth.

The White Salmon River watershed lies primarily within Klickitat County, however, the lower river below the top end of the former Northwestern Lake is shared with Skamania County, and the headwaters of the watershed also extend into Skamania and Yakima counties. These counties have a combined human population of 395,000 with less than 9,000 people living in the White Salmon watershed, http://www.ofm.wa.gov/pop/smallarea/default.asp (accessed April 11, 2012). The watershed falls within Washington State's WRIA 29b. Half of the watershed lies within the Gifford Pinchot National Forest and supports timber production and recreational uses.

Several reaches of the White Salmon River have received special designations because of their scenic value. The nine-mile reach from the confluence of Gilmer Creek near BZ Corner to Buck Creek was designated a Federal Wild and Scenic River in 1986. The upper White Salmon from the headwaters to the boundary of the Gifford Pinchot National Forest, and Cascade Creek from its headwaters to its confluence with the White Salmon River was designated as a National Wild and Scenic River in 2005. The reach from the former location of Condit Dam, RM 3.3, to the mouth is within the boundaries of the CR Gorge National Scenic Area. Recovery actions within these designated scenic areas should be coordinated with the U.S. Forest Service (USFS) to ensure the scenic values are maintained.

2.3 Ecosystem Conditions

The watershed lies within a transitional ecosystem area. Western portions of the watershed receive moderate to heavy precipitation. Eastern portions of the watershed are substantially more arid. Vegetation reflects this transitional location, with mixed forests covering about 95 percent of the watershed and grasslands and shrub steppe dominating remaining areas (Haring 2003). Trout Lake Valley, the major watershed valley, is surrounded by hills to the west and rolling plateaus to the east.

The White Salmon River and tributaries carve a watershed that is often rugged and steep, reflecting its past volcanic activity (Figure 2-6). From its headwaters, the White Salmon cuts sharply through mountains with precipitous cliffs and deeply incised canyons, dropping more than 5,000 feet in elevation before it reaches Trout Lake near RM 26, with a gradient change of 200 feet per mile (4 percent) between RM 35 and RM 30. The White Salmon loses another 1,800 feet in elevation from Trout Lake to the Columbia River. Gradient drops an average of 100 feet per mile (2 percent) from RM 17 to RM 12 as the river flows through a steep gorge with several falls. Tributaries between RM 7.6 and 16.3 are inaccessible to fish because of high falls at their mouths (NPCC 2004; WDFW and YN 1990).

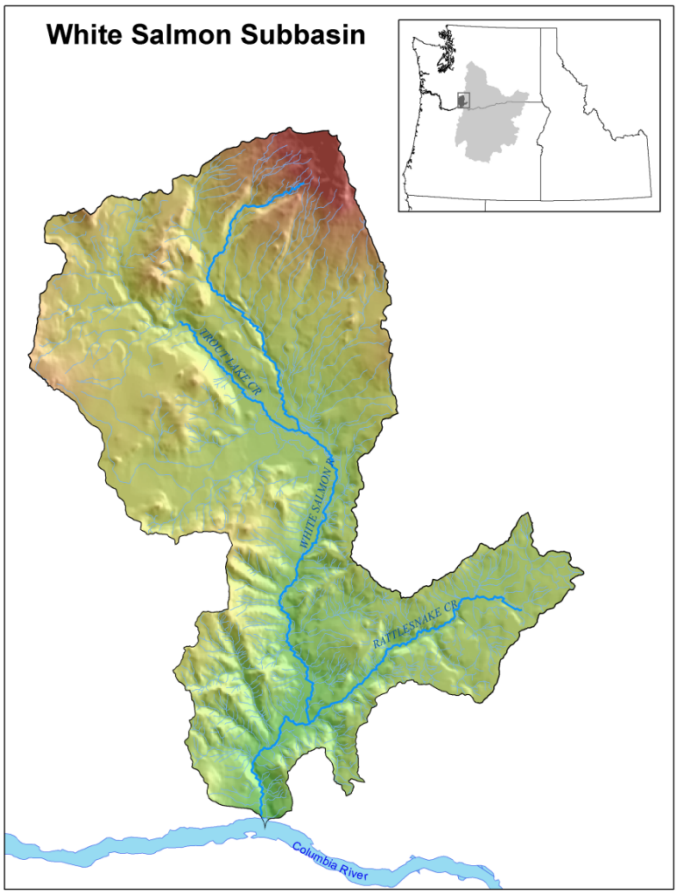


Figure 2-6. White Salmon River watershed topography and hydrology (NPCC 2004)

2.3.1 Hydrology

The White Salmon River mainstem naturally has a relatively constant natural flow pattern because of glacial melt, large water recharge, and storage capacity. Today this constant flow regime continues throughout the mainstem. Recharged water is released mostly in the middle portion of the mainstem canyon between the Trout Lake Valley and Husum Falls. Peak flows in the mainstem reflect snowmelt runoff, increasing from an average daily flow of 644 cfs during fall months to flows of 1,538 cfs in the spring (Haring 2003).

Operations at Condit Dam altered flows in the White Salmon River below the dam, causing flows to drop to as low as 15 cfs in the 1.1-mile bypass reach compared to natural flows of about 700 cfs. Power peaking at the dam affected the river system by causing diel flow variations and by impairing watershed processes, such as the transportation of spawning gravels and LWD to areas downstream of the project (NPCC 2004). The dam was breached in October, 2011 and flows will return to the natural condition as the final stages of dam removal are completed.

Tributary reaches of the White Salmon generally have more volatile flows than the mainstem, dropping to low levels in the summer and peaking in the winter. Some tributaries flow only during high flow events and are dry the remainder of the year (NPCC 2004). Some

of these tributaries may also be affected by exempted wells that can reduce recharge rates and flows.

2.3.2 Migration Barriers

Condit Dam, constructed at RM 3.3, was completed in 1913 and blocked upstream migration of anadromous fish since that time, as well as causing high mortality for outmigrating juveniles. The dam was breeched in 2011 and completely removed by October 2012. Anadromous salmonids now have complete access to habitat upstream of RM 3.3.

Prior to construction of the dam, the upstream limit of all anadromous fish migration in the White Salmon River, except for possibly Pacific lamprey, was the upper falls at Big Brother Falls, RM 16.2, which is approximately 29 feet high. Historic reports of steelhead occurring above Big Brother Falls (Lane and Lane Associates1981) were apparently large resident rainbow trout (*O. mykiss*) confused as being steelhead (Chapman et al. 1990; Bair et al. 2002). BZ Falls at RM 12.4, about 15 to 17 feet high, is likely to be the upstream limit for all salmonids, except for steelhead. Steelhead will likely be able to pass BZ Falls, but the upstream extent of the potential steelhead habitat will not extend beyond Big Brother Falls. Downstream of BZ Falls, Husum Falls, RM 7.6, was probably the historical barrier to fall-run Chinook salmon, sea-run coastal cutthroat trout, and perhaps coho salmon. Blasting shortly after the construction of Condit Dam reduced the height of the falls (Lane and Lane Associates 1981). In its current configuration, Husum Falls is not a barrier to the passage of adult resident or anadromous salmonids, except at low fall flows, and will likely be a barrier to the upstream passage of juvenile salmonids and adult chum salmon. Numerous barrier falls 4 feet in height or greater on the river between Husum and Big Brother Falls will be partial or complete barriers to the upstream migration of juvenile salmonids (LeMier and Smith 1955).

Barriers also restrict salmon and steelhead production in several White Salmon tributaries. With the exception of steelhead, and possibly coho salmon under ideal flow conditions, the falls at RM 1.5 on Rattlesnake Creek and RM 0.8 on Mill Creek will be barriers to upstream migration for all salmonids. A 4-foot high diversion dam at RM 1.9 on Buck Creek will be a barrier to the upstream migration of salmonids < 9 inches in length (Bair et al. 2002). A waterfall at RM 3.2 on Buck Creek and the hydro project dam at RM 0.7 on Spring Creek will be complete barriers to upstream salmonid migration, as is a double-fall (72-82 feet) at RM 10.6 on Rattlesnake Creek (Allen et al. 2003).

2.3.3 Riparian Function and Conditions

In comparison to other CR subbasins, the White Salmon watershed is lightly to moderately developed. However, historical logging practices, including mainstem splash damming, and associated road building and inappropriate riparian grazing have likely resulted in modification of flows, increased sedimentation, reduced riparian vegetation, loss of LWD, and increased summer temperature in some areas (NPCC 2004).

Until 1974, timber harvest typically extended to the edge of the stream/river. These practices were restricted in 1974 and have been further restricted in subsequent modifications of the Washington State Forest Practices Rules

http://www.dnr.wa.gov/Publications/fp_rules_history.pdf (accessed April 11, 2012). Additionally, the USFS prohibits harvest in riparian areas along fish bearing streams www.reo.gov/general/aboutNWFP.htm (accessed July 13, 2010).

Grazing has occurred since the late 1800s in the Rattlesnake Creek watershed and Trout Lake Valley, reducing native vegetation. Large historic marsh areas in the upper Rattlesnake Creek watershed were drained in the early 1900s to improve grazing conditions (Haring 2003). Today timber practices have improved, grazing is better managed, and wetland draining has stopped. Nevertheless, many impacts of past land use actions remain in the watershed (Haring 2003). Residential development is occurring with increasing frequency in the lower watershed and along State Route 141; however, construction within the riparian area is largely prohibited.

Some habitat areas in the White Salmon River and tributaries remain healthy, but land use activities affect many areas. EDT modeling results suggest that mainstem habitat is in better shape than tributary habitat, with maximum temperatures, minimum temperatures, and dissolved oxygen remaining at optimum levels (Allen and Connolly 2005). The EDT modeling was completed prior to removal of the dam in 2011, and the model results do not reflect current conditions in the former lakebed or downstream of the dam. New data collected since the modeling was completed indicate that temperature meets Washington state water quality standards throughout the anticipated anadromous range with the exception of Rattlesnake Creek, which occasionally approaches lethal temperatures in some locations in some years (White and Plumb 2004; White and Plumb 2005; White and Cochrane 2005; Connolly 2003; Morris 2005). Habitat surveys completed in the watershed indicate that large wood and pools are low in frequency throughout the Rattlesnake watershed and many of the existing pools are of poor quality (shallow with little cover) (Allen and Connolly 2006a). Unscreened diversions in some locations may potentially affect juvenile survival. Nutrient levels in many portions of the watershed are quite high, up to two times the EPA recommended standard (White and Plumb 2004, 2005; White and Cochrane 2005, Environmental Protection Agency (EPA) 2000).

2.4 Life History Characteristics

2.4.1 White Salmon River Chinook salmon

This section describes fall and spring Chinook salmon populations in the White Salmon River watershed.

Abundance and Productivity

The W/LC TRT recognizes two historical independent Chinook salmon populations in the watershed: White Salmon River fall-run Chinook salmon and White Salmon River spring-run Chinook salmon (Myers et al. 2003; Myers et al. 2006). These historical Chinook salmon populations are considered to be part of the Gorge stratum (or Major Population Group (MPG)) of the lower Columbia Chinook salmon ESU (Myers et al. 2006). These populations are described below.

Fall Chinook salmon

Biologists consider tule fall Chinook salmon native to the system, although the historical size of the fall-run to the White Salmon River is unknown. Past hatchery records indicate that fall-run Chinook salmon in the LWS and White Salmon rivers began spawning in early September, with peak egg takes in the later part of the month (September 21, 1901); 12,840,700 eggs were collected in 1901 (Myers et al. 2003; Myers et al. 2006; Bowers, 1902).

The current stock origin for the naturally spawning tule fall Chinook salmon is considered mixed (NOAA 2005). Hatchery tule fall Chinook salmon were last released in the White Salmon River in the 1980s, but strays are commonly recovered in the river (WDFW 2003). The Spring Creek NFH is located on the CR approximately one mile west of the mouth of the White Salmon River.

Most of the fish spawning naturally in the White Salmon River were assumed to be hatchery-origin tule fall Chinook salmon based on CWT recoveries. The USFWS (2004) estimated natural-origin fall Chinook salmon escapement in the White Salmon River by subtracting the hatchery component calculated by expanding the number of CWT recovered during carcass surveys by the Spring Creek Hatchery brood year tag rate from the total tule escapement (Figure 2-7). Spring Creek NFH began marking all of its hatchery production in 2004 and as a result, recent spawning ground surveys have shown that the majority of the tule fall Chinook salmon returning to the White Salmon River are of natural origin (Roler 2011). The total number of fall Chinook salmon spawners (natural-origin and hatchery) has averaged 2,750 from 1998-2007, even with low returns in the early 2000s (USFWS 2004; Roler 2009). The recent 10-year average (2002-2011) for escapement of natural spawning tule fall Chinook salmon in the White Salmon River has increased to 3,127 adults (Roller 2012). Smith et al. (2007) determined that Spring Creek NFH tule fall Chinook salmon and natural-origin fall tule fall Chinook salmon in the White Salmon were genetically similar and were distinct from other tule fall Chinook salmon populations in the LCR ESU. Natural spawning tule fall Chinook salmon were also found to have not interbred with URB fall Chinook salmon that also spawn in the White Salmon River (Smith and Engle 2011).

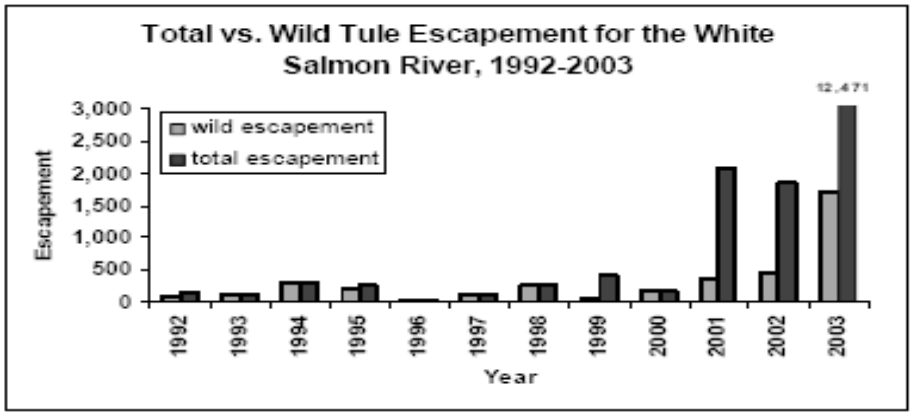


Figure 2-7. Wild and total tule fall Chinook salmon escapement for the White Salmon River from 1992-2003 (USFWS 2004)

Spring Chinook salmon

Biologists generally believe the White Salmon spring Chinook salmon population was historically significant, but declined to low numbers after construction of Condit Dam (LCFRB 2004). Fulton (1968) speculated that Chinook salmon historically caught by tribal members upstream of Husum Falls were likely spring Chinook salmon, citing Bryant (1949) and USFWS (1951) but these reports did not indicate direct observations of spring Chinook salmon. Evermann and Meek (1898) surveyed the White Salmon River in August and September and did not observe Chinook salmon in August, however, the conditions were not conducive to observation due to flooding from the CR, and only the lower mile of the river was investigated. If the life history timing of the White Salmon spring Chinook salmon were similar to other LCR spring Chinook salmon populations, adult spring Chinook salmon would be expected to be on the spawning grounds in the upper river during the month of August, not entering their natal river. Lane and Lane Associates (1981) document early indications of the presence or absence of spring Chinook salmon in the White Salmon River. Some of the persons interviewed remembered the presence of spring Chinook salmon, while others could not verify these observations. The W/LC TRT deduced that there was an historical population of spring Chinook salmon in the White Salmon River (Myers et al. 2006).

LeMier and Smith (1955) evaluated the capacity of the White Salmon River to support salmon if passage was provided upstream of Condit Dam. Under conditions existing in 1955, they estimated the White Salmon River could support 732 spring Chinook salmon and 452 fall Chinook salmon, but noted that conditions in the White Salmon River were degraded substantially in 1955 relative to historical levels. Chapman (1981), using instream flow measurements, estimated that in pristine conditions prior to the construction of Condit Dam the White Salmon River supported 625 adult Chinook salmon (spring and fall runs combined). Using similar methods, Young and Rybak (1987) estimated that the habitat upstream of Northwestern Reservoir could support 35,000 spring Chinook salmon smolts, and from 140 to 1,120 spring Chinook salmon adults. Chapman (1981) and Young and Rybak (1987) noted that the watershed has cool summer water temperatures and deep canyon pools, conducive to spring Chinook salmon holding and rearing. The EDT modeling effort estimated capacity for approximately 560 to 650 spring Chinook salmon in the watershed. W/LC TRT members generally believe that the construction of Condit Dam extirpated spring Chinook salmon in the White Salmon River and eliminated the genetic resources of the population (McElhany et al. 2004, p. 71). As recently as 2009, stray hatchery spring Chinook salmon have been observed holding and spawning below Condit Dam, but their reproductive success is unknown (McElhany et al. 2004; NPCC 2004; Engle et al. 2010).

Spatial Structure and Diversity

Prior to the construction of Condit Dam, spring Chinook salmon probably ranged up the White Salmon River to above Husum Falls, RM 12, and probably up to Big Brother Falls at RM 16.2 (Chapman 1981; Young and Rybak 1987). They may have also migrated into Rattlesnake Creek (NPCC 2004). Fall Chinook salmon were limited to spawning and rearing habitat below Husum Falls (NPCC 2004). This conclusion was confirmed using Radio-tagged adult fall Chinook salmon released above Condit Dam (Engle and Skalicky 2009).

Since 1913, Condit Dam has limited distribution for Chinook salmon to the 3.3-mile area below the dam. While the dam was in place, Chinook salmon spawned and reared in the lower White Salmon River below Condit Dam, (Figure 2.8). Most of these spawners were fall Chinook salmon and many were hatchery strays. In 2011, fisheries co-managers transported and released upstream of Northwestern Lake naturally spawning Chinook salmon entering the White Salmon River in order to preserve the year class. Any redds present downstream of the dam when it was breached would have been destroyed though scour and subsequent deposition of sediments.

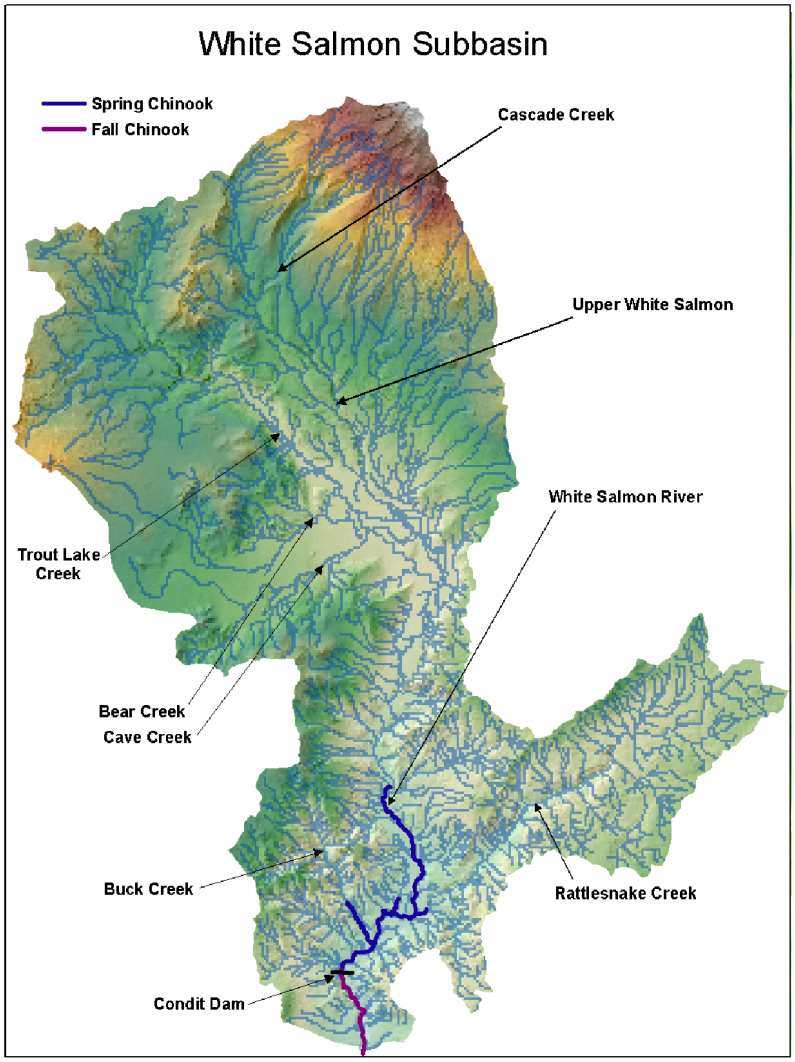


Figure 2-8. Possible extent of historic spawning distribution of Chinook salmon in the White Salmon River (NPCC 2004)

Key Habitat during Different Life Stages

Biologists consider White Salmon River fall-run Chinook salmon an ocean-type salmon because they migrate to the ocean as subyearlings. Tule Chinook salmon begin entering the CR in early August, with the greatest abundance in the estuary between late August and early September. Tule counts at Bonneville Dam generally peak between September 4 and

September 9. Most tules mature at age three, with very few five-year-olds. Fall Chinook salmon spawning in the White Salmon River peaks in late September through early October. The adults tend to spawn in mainstem rivers and large tributaries.

Since human activities have extirpated native spring-run Chinook salmon in the White Salmon River, scientists know little about their life history. Biologists would expect the historical spring-run Chinook salmon population to have a life history similar to other LCR ESU spring Chinook salmon populations. These spring Chinook salmon are a stream type because they primarily smolt as yearlings. Fecundity varies within and among Chinook salmon populations. Adult spring-run Chinook salmon enter the Columbia River from February to Mid-May and spawn from late July to late September (Fulton 1968).

Both fall and spring Chinook salmon generally spawn in stream reaches at least 10 feet wide. They construct redds in gravel and small cobble substrate in pool tailouts, riffles, and glides. Eggs remain in the gravel until emergence, which occurs from February to April depending on water temperatures. Emerging fry seek out shallow, low velocity areas in the stream channel, preferring backwater and dammed pools, along with glides. Shortly after fry colonization, however, tule fall Chinook salmon juveniles begin their outmigration, while the spring Chinook salmon juveniles can continue rearing until October. During the inactive or overwintering life stage, spring Chinook salmon juveniles prefer non-turbulent deeper water habitat types (primary pools) in the main channel, but also use slower portions of large cobble riffles. Yearling spring Chinook salmon outmigrate during the following spring.

Table 2-1 shows key habitat for fall and spring Chinook salmon during different life stages.

Table 2-1. Key habitat by life stage and time period for fall/spring Chinook salmon (NPCC 2004)

Life Stage	Relevant Months	Key Habitat Descriptions
Spawning	Tule Sep-Oct Spring Aug-Sep	Riffles, tailouts, and the swifter areas in glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	Aug-May	Riffles, tailouts, and the swifter areas of glides as described for spawning with sufficient flow for egg and alevin development
Fry Colonization	Feb-May	Shallow, slow velocity areas within the stream channel, including backwater areas, often associated with stream margins and back eddies and usually in relatively low gradient reaches
Active Rearing	Tule Feb-June Spring Mar-Oct	Relatively slow water habitat types, often near velocity shears, often associated with relatively low gradient stream channel reaches, including primary pools, backwaters, tailouts, glides, and beaver ponds
Inactive Rearing	Oct-Mar	Non-turbulent habitat types, particularly deeper water types within the main channel, but also including slower portions of large cobble riffles
Migrant	Tule, Age 0 Mar-Jun Spring, Age 1 Mar-May	All habitat types having sufficient flow for free movement of juvenile migrants

Life Stage	Relevant Months	Key Habitat Descriptions
Pre-spawning Migrant	Tule Aug-Oct Spring Feb-Sep	All habitat types having sufficient flow for free movement of sexually mature adult migrants
Pre-spawning Holding	Tule Aug-Oct Spring Aug-Sep	Relatively slow, deep water habitat types typically associated with (or immediately adjacent to) the main channel

2.4.2 White Salmon River coho salmon

Myers et al. (2006) included the historic coho salmon population in the White Salmon River as part of the Gorge Stratum within the lower Columbia coho salmon ESU. This section describes the White Salmon River coho salmon population.

Abundance and Productivity

The W/LC TRT determined that coho salmon are native to the White Salmon River based on habitat and historical presence of coho salmon in other CR gorge tributaries (Myers et al. 2006). Rich (1938) indicated that only a very small portion of the total CR coho salmon run migrated beyond Bonneville Dam. None of the early surveys of fisheries identified coho salmon in the White Salmon River, although the timing of these surveys did not coincide with coho salmon presence. Interviews with long-term residents and notes found in diaries indicate that coho salmon were likely present, but in low numbers (Lane and Lane Associates 1981; Cobb 1924).

Chapman (1981), using instream flow measurements, estimated that in pristine conditions prior to the construction of Condit Dam the White Salmon River supported 5,489 adult coho salmon. Young and Rybak (1987) estimated that the habitat could support 45,000 coho salmon smolts, and from 1,600 to 2,300 coho salmon adults. Scientists consider the current population in the White Salmon River extirpated (Johnson et al. 1991; Weitkamp et al. 1995; Schiewe 1996; Good et al. 2005). Good et al. (2005) suggested that recovery efforts could use existing hatchery programs to build naturally spawning populations. Currently, the size of this population is unknown. In a 2004 population status evaluation, W/LC TRT members found insufficient data to determine the productivity and abundance of the White Salmon River coho salmon population (McElhany et al. 2004). Some members noted that construction of Condit Dam probably resulted in the population's extirpation, as most historical spawning habitat for the population lies above the dam. Myers et al. (2006) in designating the historical population structure for coho salmon in the Gorge strata identified two populations above Bonneville Dam: Oregon tributaries and Hood River and Washington tributaries and the White Salmon River (including the Wind River, Spring Creek, and the LWS River).

The LCFRB Recovery Plan (LCFRB 2004) proposed an abundance goal for recovery of 150 fish. However, potential production estimates for coho salmon in the White Salmon River, completed for the NPCC subbasin planning (Allen and Connolly 2005; NPCC 2004) and for other efforts (Chapman et al. 1990; Washington Department of Fisheries (WDF) 1990) suggest that the drainage could support 950 to 2,300 coho salmon, if decision makers and scientists are able to restore passage to historical habitats above the dam.

Spatial Structure and Diversity

With the removal of Condit Dam, habitat that could potentially support coho salmon extends from the mouth up to RM 14 in the mainstem and into Buck, Spring, Indian, and Rattlesnake creeks (Figure 2-8) (NPCC 2004). This range may provide up to 21 miles of spawning and rearing habitat for coho salmon, with most potential spawning habitat above the location of

the former Condit Dam. Prior to breaching the dam, hatchery strays occasionally use the area below Condit Dam (NPCC 2004).

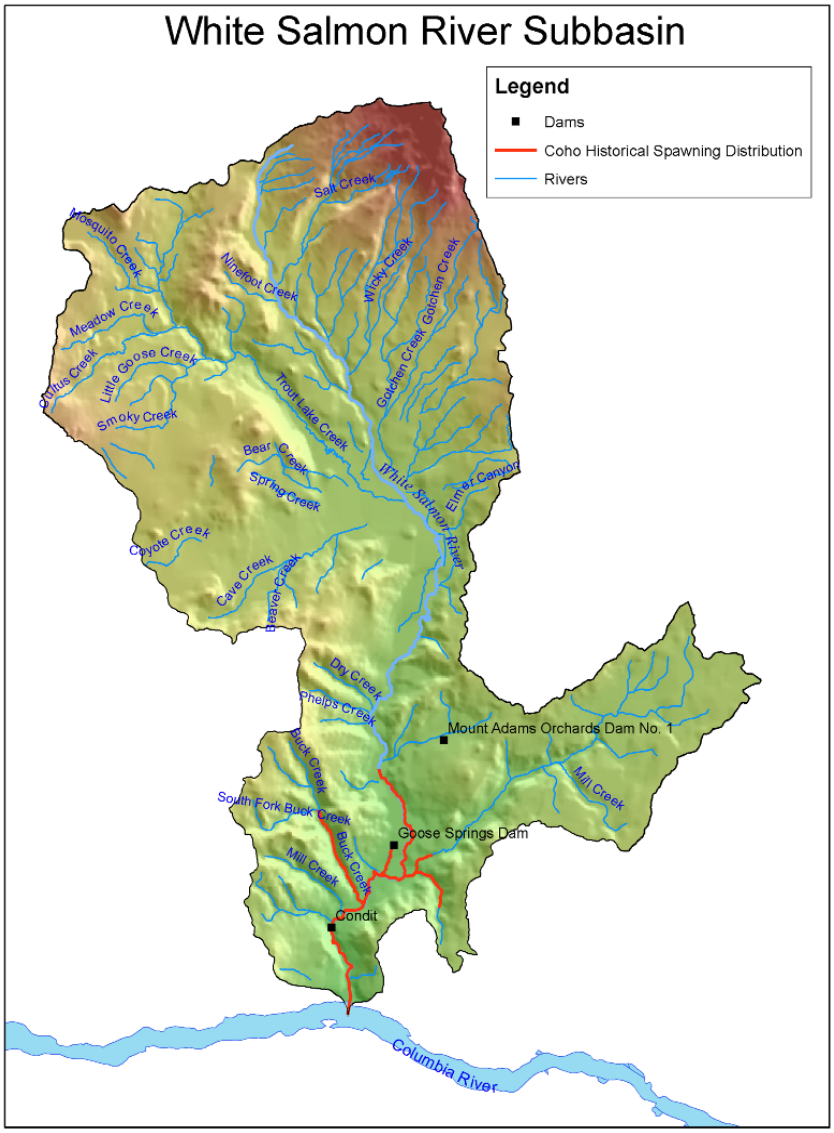


Figure 2-9. Potential extent of historical spawning distribution of coho salmon in the White Salmon River (McElhany et al. 2004)

Key Habitat during Different Life Stages

LCR coho salmon adults typically return to their spawning rivers from September through November, and typically spawn from October through January, with peak activity in November. Redds are constructed in gravel and small cobble substrate in pool tailouts, riffles, and glides, with sufficient flow depth for spawning activity. The eggs incubate in the gravel from October to May and generally emerge from February to April, depending on water temperatures. Emerging fry migrate to shallow, low velocity areas, which are associated with stream margins and back eddies.

After fry colonization, juvenile coho salmon seek out slow water habitat types near velocity shears, which are often associated with relatively low gradient stream reaches where they continue rearing until October. Preferred areas are primarily backwater and dammed pools. As winter approaches, juveniles become inactive and prefer off channel pool habitat over primary pool habitat for overwintering. Coho salmon yearling migration occurs the following spring, peaking in May.

Table 2-2 describes key habitat by life stage.

Table 2-2. Key habitat by life stage and time period for White Salmon River coho salmon (NPCC 2004)

Life Stage	Relevant Months	Key Habitat Descriptions
Spawning	Oct-Jan	Riffles, tailouts, and the swifter areas in glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	Oct-May	Riffles, tailouts, and the swifter areas of glides as described for spawning with sufficient flow for egg and alevin development
Fry Colonization	Mar-May	Shallow, slow velocity areas within the stream channel, including backwater areas, often associated with stream margins and back eddies and usually in relatively low gradient reaches
Active Rearing	0-age Mar-Oct 1-age Mar-May	Relatively slow water habitat types, often near velocity shears, often associated with relatively low gradient stream channel reaches, including primary pools, backwaters, tailouts, glides, and beaver ponds
Inactive Rearing	Oct-Mar	Non-turbulent habitat types, particularly deeper water types within the main channel, but also including slower portions of large cobble riffles
Migrant	Mar-May	All habitat types having sufficient flow for free movement of juvenile migrants
Pre-spawning Migrant	Sep-Nov	All habitat types having sufficient flow for free movement of sexually mature adult migrants
Pre-spawning Holding	Oct-Dec	Relatively slow, deep water habitat types typically associated with (or immediately adjacent to) the main channel

2.4.3 Upper Gorge chum salmon

This section describes the segment of the upper Gorge chum salmon population that historically occupied the White Salmon River.

Abundance and Productivity

Chum salmon that returned to the White Salmon River were part of the upper Gorge Tributaries population (McElhany et al. 2004). Annual fish passage reports by the U.S. Army Corps of Engineers (USACE) (2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008), for Bonneville Dam provided data that adult chum salmon continue to pass upstream of Bonneville Dam, with adult counts averaging 139 from 2000 to 2008 and ranging from a

low of 49 to a high of 411. Recent chum salmon surveys by WDFW have identified fewer than five chum salmon carcasses above Bonneville Dam annually; no carcasses were observed in 2005 (Jenkins 2006), however researchers in Oregon observed chum salmon spawning at the mouth of Eagle Creek above Bonneville Dam in 2008 and 2009 (M. Weeber, personal communication 2010). Today, chum salmon are limited almost exclusively to habitats downstream of Bonneville Dam, with most spawning in Washington waters.

Biologists know little about the chum salmon production potential of the LCR or the White Salmon River. Chum salmon fecundity data are variable. In North America, the literature reports individual fecundity ranged from 2,018 to 3,977 eggs per female (Salo 1991). Fecundity data are available for wild chum salmon in the LCR, but not for the White Salmon River. Chum salmon broodstock collected from the lower Gorge population in 2007 had an average fecundity of 2,255 eggs and a range of 1,630 to 2,922 eggs (Hillson 2009).

In the upper Gorge Tributaries population, researchers assumed a 96 percent reduction in abundance due to the existence and operation of Bonneville Dam. They assumed impacts to be predominantly due to inundation of historical habitat by the reservoir (see spatial structure and diversity below), but to include about 5 percent passage mortality for juveniles and an additional 3 percent for adults (Tables 14-1 and 14-2 in NMFS 2008b).

Spatial Structure and Diversity

Small et al. (2006) analyzed genetic samples from populations in the coast, cascade, and gorge regions of the CR chum salmon ESU. They found significant heterogeneity in genotype distributions between zones and that collections formed regional groups in a neighbor joining tree. Cascade collections had higher allelic richness and private alleles, and the Cowlitz River supported genetically divergent fall and summer runs, the only summer chum salmon run extant in the CR drainage. They propose that chum salmon in the Cascade zone are remnants of original populations and they attributed the divergence between zonal groups to diverse ecological conditions in each zone, which promoted regional genetic adaptation, and to genetic drift experienced in small populations. No information is available regarding the historical diversity for chum salmon in the White Salmon River.

In the White Salmon River, the pool behind Bonneville Dam has inundated approximately 80 percent of the historical chum salmon spawning habitat, rendering it unusable (NPPC 2004).

Key Habitat during Different Life Stages

Chum salmon usually spawn in lower river reaches, dig their redds in the mainstem, tributaries or in side channels and tend to use shallower, slower running streams and side channels more frequently than do other salmonids. Water velocity in spawning areas varies widely for chum salmon. In Washington, Johnson et al. (1991) measured water velocities near 1,000 chum salmon redds and found that velocities where fish spawned varied from 0.0 to 5.5 ft/sec (0.0 to 167.6 cm/sec), and that over 80 percent of the fish spawned in velocities between 0.7 and 2.7 ft/sec (21.3 and 83.8 cm/sec). This range is similar to that found in other species of salmon.

One detectable difference between chum salmon populations in different areas is the time it takes for eggs to incubate, hatch, and emerge as alevins from the gravel. Differences

between populations are caused by physical factors such as stream flow, water temperature, dissolved oxygen, and gravel composition, and by such biotic factors as genetics, spawning time, and spawning density, all of which can affect survival (reviewed in Bakkala 1970; Salo 1991). Scientists believe water temperature has the most influence on the rate of embryonic development in chum salmon (reviewed in Bakkala 1970; Koski 1975; Salo 1991). The amount of heat, measured in Thermal Units (TUs), required by fertilized chum salmon eggs to develop and hatch is about 400-600 TUs, and the heat required to complete yolk absorption is about 700-1,000 TUs. Lower water temperatures can prolong the time required from fertilization to hatching by 1.5-4.5 months.

Chum salmon do not typically have substantial freshwater rearing time. Most chum salmon juveniles begin seaward migration with minimal time spent in natal streams. Consequently, the period of estuarine residence appears to be the most critical phase in the life history of chum salmon and may play a major role in determining the size of the subsequent adult-run back to fresh water. Chum salmon juveniles, like other anadromous salmonids, use estuaries to feed before beginning long distance oceanic migrations. However, chum salmon and ocean-type Chinook salmon usually have longer residence times in estuaries than do other anadromous salmonids (Dorcey et al. 1978; Healey 1982).

Biologists know little about the seaward migration of juvenile chum salmon from the Columbia River. Generally, however, researchers find migration of chum salmon juveniles out of estuaries appears to closely correlate with prey availability (LCFRB 2004). For information about conditions in the CR Estuary and how chum salmon may be affected, see the Proposed CR Estuary ESA Recovery Plan Module for Salmon & Steelhead http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm (accessed April 11, 2012).

2.4.4 White Salmon River steelhead

Oncorhynchus mykiss, of which steelhead and rainbow trout are members, displays a wide variety of life history strategies (Busby et al. 1996). Anadromy is not obligatory in *O. mykiss*, but scientists extensively debate the heritability of anadromy (Rounsefell 1958; Mullan et al. 1992). Progeny of anadromous steelhead can spend their entire lives in freshwater (residualize), while progeny of rainbow trout can migrate seaward. The White Salmon River watershed supports both forms of *O. mykiss*. Although rainbow trout are not in the MCR steelhead DPS, genetic analysis shows that White Salmon steelhead and rainbow trout are an inland race of *O. mykiss* (Phelps et al. 1990; Phelps et al. 1994). The White Salmon population is as part of the Cascade Eastern Slope Tributaries MPG (Figure 2-10).

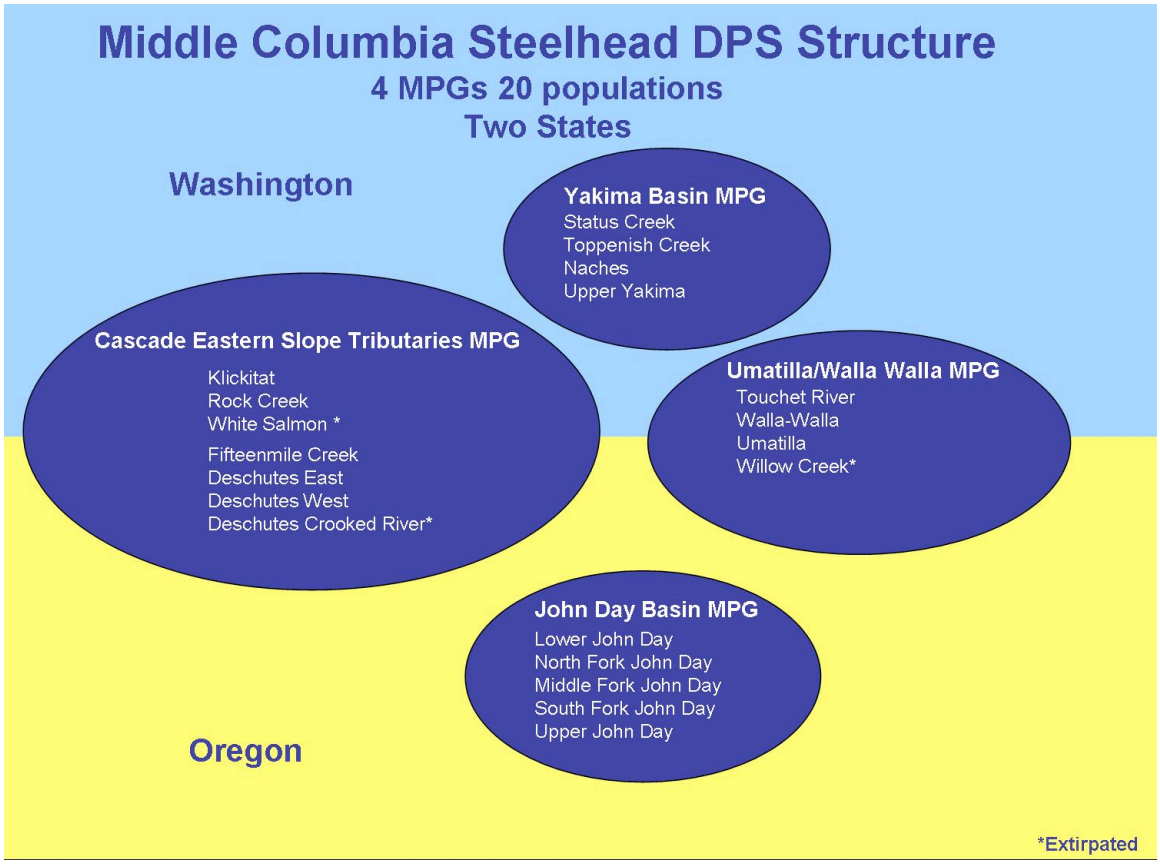


Figure 2-10. Major Population Groups (MPGs) and populations of middle Columbia steelhead. Note the White Salmon steelhead population is considered functionally extirpated (ICTRT 2007b)

Some biologists believe that residual steelhead populations in the form of resident trout may contribute to anadromy in the watershed. Phelps et al. (1990) found that introgression from hatchery rainbow plants was not evident in wild rainbow trout samples and high levels of genetic diversity still exist in this population. Seiler and Neuhauser (1985) caught more steelhead smolts than were predicted by the modeling. One hypothesis is that resident rainbow trout spawning upstream of the former Condit Dam continue to produce some steelhead smolts, indicating that anadromous *O. mykiss* has maintained genetic diversity and fitness (NPCC 2004).

Pre-removal monitoring in the White Salmon River above Condit Dam has identified *O. mykiss* juveniles displaying smolt behavior and morphology, and PIT-tagged juveniles have been detected passing Bonneville Dam with one being recovered at the tern colony on East Sand Island (B. Allen, personal communication, 2007). In addition, a juvenile *O. mykiss* PIT-tagged above Condit Dam September of 2004 at 98 mm was detected ascending Bonneville Dam in July of 2006. Genetic analysis of juvenile *O. mykiss* collected in the upper watershed above Husum Falls are different from hatchery trout released in the basin, however additional samples are needed to confirm this finding (Allen et al. 2006). This information supports the theory that even though the population is functionally extirpated

there is still the potential for re-establishing anadromous steelhead in the White Salmon River Basin.

Biologists divide steelhead into two basic run types based on the salmonid species' level of sexual maturity at the time they enter fresh water and the duration of the spawning migration. The stream maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in fresh water to mature and spawn. The ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns relatively shortly after river entry (Bambrick et al. 2004). Based on habitat conditions and the composition of nearby populations, it is likely that the White Salmon River population historically supported both summer and winter life history patterns (ICTRT 2008). Chapman (1981), using instream flow measurements, estimated that in pristine conditions prior to the construction of Condit Dam, the White Salmon River supported 763 adult steelhead. Young and Rybak (1987) estimated that the habitat could support 39,000 steelhead smolts, and 2,770 adults.

Key Habitat during Different Life Stages

Steelhead generally return to the White Salmon River between April and October, although some hold over in the CR throughout the year and enter the river as they approach spawning. Wild steelhead spawn from February to June with peak spawning in April. Hatchery-reared summer steelhead in the White Salmon River watershed, however, typically spawn earlier, from December to February, with peak activity in January. Steelhead spawning and rearing currently occurs in the lower White Salmon and will occur in both mainstem and tributary habitats after dam removal.

Steelhead eggs incubate in their gravel beds for four to seven weeks, depending on water temperature, before hatching. After emergence, the small fry seek shallow, slow velocity areas within the stream channel, often associated with stream margins. As young steelhead mature they move into water with increasing depth and velocities. Juvenile steelhead typically spend two to three years in freshwater before outmigrating to the ocean. They typically move to interstitial spaces between cobble and boulders for cover during the fall, and remain in this habitat until March. In April, they return to a more active rearing life stage and seek out suitable habitat types. Outmigration occurs in spring and typically peaks in early May (NPCC 2004). Table 2-3 shows key habitat for steelhead during different life stages.

Some steelhead are iteroparous (do not die after spawning). A small proportion of repeat spawners, known as kelts, may return to the ocean for a short period and repeat the spawning migration, a life history adaptation that may be fundamental to ensuring population stability. Iteroparity for Mid-Columbia steelhead ranges from reported rates of 2-4 percent above McNary Dam (at RM 292 measured from the mouth of the Columbia) (Busby et al. 1996) up to 17 percent in the unimpounded tributaries below Bonneville Dam (at RM 146.1) (Leider et al. 1986). Iteroparity rates of summer and winter steelhead in the Kalama River, a tributary to the CR below Bonneville Dam have been estimated at 15 percent and 21 percent respectively (Withler 1966; Leider et al. 1986), while repeat spawners in the Hood River, an Oregon tributary in the impounded Bonneville Pool above Bonneville Dam, make up 9

percent of the summer and 13 percent of the winter-run of steelhead (Olsen 2004). The combined sampling from 1979 to 1981 (Howell et al. 1985) and the 2005 adult trapping data from YN and WDFW reported iteroparity rates for Klickitat River steelhead at 3.2 percent. Sampling of adults at the Klickitat River's Lyle Falls Fishway in 2004 and 2005 has indicated repeat spawning rates of 2.9 percent for summer steelhead and 8.8 percent for winters. Most repeat spawners are females. Iteroparity is a life history trait that should be assessed once steelhead re-colonize the White Salmon River and taken into account when management decisions for White Salmon steelhead are made.

Table 2-3. Key habitat by life stage and time period for steelhead (NPCC 2004)

Life Stage	Relevant Months	Key Habitat Descriptions
Spawning	Mar-Jun	Riffles, tailouts, and glides containing a mixture of gravel and cobble sizes with flow of sufficient depth for spawning activity
Incubation	Mar-Jun	Riffles, tailouts, and glides as described for spawning with sufficient flow for egg and alevin development
Fry Colonization	May-Jul	Shallow, slow velocity areas within the stream channel, often associated with stream margins
Active Rearing	0-age May-Jul; 1-age, Mar-Oct; 2+-age, Mar-Oct	Gravel and cobble substrates with sufficient depth and velocity, and boulder/large cobble/wood obstruction to reduce flow and concentrate food
Inactive Rearing	0,1-age Oct-Mar	Stable cobble/boulder substrates with interstitial spaces
Migrant	1-age, Mar-Jun 2+-age, Mar-Jun	All habitat types having sufficient flow for free movement of juvenile migrants
Pre-spawning Migrant	Winter, Nov-Apr Summer, All	All habitat types having sufficient flow for free movement of sexually mature adult migrants
Pre-spawning Holding	Winter, Dec-May Summer, All	Relatively slow, deep water habitat types typically associated with (or immediately adjacent to) the main channel

2.5 Hatchery Production and Releases

Fall Chinook salmon

No hatchery fall Chinook salmon are released directly in the White Salmon River watershed; however, hatchery tule fall Chinook salmon from Spring Creek NFH do stray into the watershed, contributing to natural production. Fish technicians have also recovered hatchery-origin URB fall Chinook salmon in the White Salmon River. These URB fall Chinook salmon are primarily from the LWS NFH, Bonneville Hatchery, and Klickitat Hatchery programs and are not part of the LCR Chinook salmon ESU. Biologists and recovery planners are considering Spring Creek NFH tule fall Chinook salmon for use in the reintroduction of fall Chinook salmon after PacifiCorp completes decommissioning of Condit Dam. This program is described below.

Spring Creek NFH Tule fall Chinook salmon

Hatchery managers used fall Chinook salmon from the White Salmon River to establish the Spring Creek NFH fall Chinook salmon program; the hatchery program is part of the LCR Chinook salmon ESU. The program uses only returns to the hatchery for broodstock, but has incorporated other tule stocks in the past. Hatchery workers last released non Spring Creek NFH tule fall Chinook salmon from the hatchery in 1991; the fish were Bonneville tule fall Chinook salmon. The Spring Creek NFH tule fall Chinook salmon is the most representative of the native Chinook salmon population that was historically present in the White Salmon River.

The hatchery program mitigates for lost and degraded habitat because of the construction and operation of the CR hydrosystem by producing locally adapted broodstock for sport, commercial, tribal, and international harvest. The production goal for the current program is for an on-station release of 10,500,000 sub-yearlings annually, with 1,700,000 acclimated and released at the LWS NFH, and 2,800,000 eggs transferred downstream to the Bonneville State Hatchery. This production requires a minimum of 7,000 adults (4,000 females). As mentioned previously, recovery planners are considering fall Chinook salmon from the program for reintroduction into the watershed once decommissioning of Condit Dam is completed. Genetic analysis of naturally spawning fall Chinook salmon in the White Salmon and other Bonneville Pool tributaries determined that Spring Creek NFH fall Chinook salmon are representative of the naturally spawning population of fall Chinook salmon in the White Salmon River (Smith et al. 2007; Smith and Engle 2011).

Non ESU Little White Salmon NFH Upriver Bright fall Chinook salmon

Biologists collected the original source of this stock of URB fall Chinook salmon at the Bonneville State Fish Hatchery. The current source of URB fall Chinook salmon is fish returning to the LWS NFH. The URB fall Chinook salmon stock is not native to the LWS and is not considered part of the LCR Chinook salmon ESU.

The purpose of the hatchery program is to successfully rear and release URB fall Chinook salmon into the LWS, which will mitigate for lost and degraded habitat because of the construction and operation of the CR hydrosystem, meet *U.S. v. Oregon* court agreements,

and provide a 1.7 million fry release in the Yakima River Basin. The program production goal is to release 2.0 million sub-yearling URB fall Chinook salmon at the hatchery, and 2.5 million sub-yearlings that come from the Bonneville State Hatchery and are acclimated for 4 weeks before being released on-station.

Spring Chinook salmon

Presently there are no hatchery programs associated with this population, however hatchery spring Chinook salmon have been observed spawning in the White Salmon River. In 2009, biologists examined 110 spring Chinook salmon carcasses at a weir installed at RM 1.1 at the White Salmon Ponds fish facility downstream of Condit Dam (Engle et al. 2010). All the spring Chinook salmon carcasses were hatchery-origin and post-spawn, i.e., near death or in a state of decay (Engle et al. 2010). The lack of natural-origin spring Chinook salmon examined at the weir supports the observation that spawning does occur in the lower White Salmon River but rearing habitat is lacking (Engle et al. 2010).

Coho salmon

There are no hatchery programs that directly release hatchery coho salmon into the White Salmon River. The coho salmon program at the LWS NFH released coho salmon that may have contributed to straying into the White Salmon River in the past, but stray rates were not estimated. The LWS NFH discontinued the program after releases in 2004 because of funding shortfalls. Stray coho salmon currently entering the White Salmon River may come from releases in the Klickitat and Umatilla rivers and from Bonneville Hatchery.

Chum salmon

Historical and current hatchery influences on chum salmon are minimal. Hatcheries have released chum salmon into only 4 of 10 Washington populations. Hatchery fish do not comprise a substantial fraction of any naturally spawning chum salmon population and all originate from local wild populations. Current chum salmon hatchery programs focus on reintroduction (Chinook River) and conservation (Duncan Creek, and Grays River) (LCFRB 2004).

Steelhead

Scientists and recovery planners do not consider the hatchery programs in the White Salmon River watershed to be part of the MCR steelhead DPS. From 1995 to 2010, fisheries co-managers annually released both summer and winter steelhead smolts from broodstock collected at the Skamania Hatchery on the West Fork of the Washougal River into the White Salmon River below Condit Dam. The summer steelhead broodstock derives from summer steelhead from the Washougal and Klickitat Rivers. The winter steelhead broodstock derives from returns to the Washougal River.

The Skamania Hatchery program goal was to provide fisheries for summer and winter steelhead in the White Salmon River as mitigation for losses from human development and concomitant habitat loss and to meet the obligations of the *U.S. v. Oregon* agreement. The program involved an annual release of 24,000 summer and 20,000 winter steelhead smolts, although actual releases varied from year to year. Production consisted of adipose-fin-clipped fish to allow for selective fisheries and to facilitate assessment of the ratio of

hatchery adults to wild adults. Workers trucked smolts from Skamania Hatchery and stream-released them into the White Salmon River at RM 1.5. Fish managers terminated the program with the 2009 releases.

Biologists would need to develop or identify a more suitable broodstock to expedite the reintroduction of steelhead in habitats upstream of the former Condit Dam. Monitoring steelhead escapement and production, after dam decommissioning is complete, will determine whether there are impacts from these Skamania Hatchery releases.

2.6 Harvest

Primarily ocean and mainstem CR commercial, tribal, and sport intercept Chinook salmon and coho salmon. Tributary sport fisheries also harvest some Chinook salmon and coho salmon. The LCFRB recovery plan (LCFRB 2004) and the ESA section 7 Biological Opinion for fisheries managed under the *U.S. v. Oregon* Agreement (NMFS 2008c) describe in detail harvest management and harvest effects.

In 2012, the fisheries regulations in the White Salmon River prohibited the retention of unmarked Chinook salmon from April 1 to July 31, and unmarked Chinook salmon and coho salmon from August 1 to March 31, in the area from the mouth to the Northwestern Lake Road bridge (WDFW 2012).During the removal of Condit Dam the White Salmon was closed to fishing from the Northwestern Lake Road bridge downstream to the old county road bridge below the powerhouse. Regulations also prohibit the retention of chum salmon in tributary recreational fisheries.

Steelhead harvest, while locally important, was historically likely less substantial than salmon harvest because of lower abundance and spawning times that coincided with higher flows (NPCC 2004). The YN reports that tribal members fished for salmon and steelhead historically as high as Husum Falls and Rattlesnake Falls on the White Salmon River (J. Meninick, YN Cultural Resources Department, personal communication, 2006). Section 5.4, Harvest, for an expanded discussion of harvest impacts.

3 Recovery Goals and Viability Criteria

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act, i.e., NMFS delists the species. Recovery plans may also contain "broad-sense goals," defined in the recovery planning process as going beyond the requirements for delisting to address, for example, other legislative mandates or social, economic, and ecological values.

NMFS applies the delisting criteria at the ESU/DPS level based on determinations of the viability of the independent populations that make up the ESU/DPS. The LCR ESA Recovery Plan describes the criteria for delisting the LCR ESUs. As noted, this Plan is an appendix of the LCR ESA Recovery Plan. The middle Columbia Steelhead ESA Recovery Plan describes the criteria for delisting the MCR Steelhead DPS. This plan is also an appendix to the middle Columbia Steelhead ESA Recovery Plan. This chapter provides recovery goals for the White Salmon River Chinook salmon, coho, chum salmon, and steelhead populations and describes the criteria NMFS will use to assess progress toward those goals and the role of the White Salmon River salmon populations in overall ESU/DPS viability.

There are two kinds of criteria that enter into a delisting decision: biological criteria defining viable populations (section 3.2, Biological Viability Criteria) and "threats" criteria related to the five listing factors detailed in the ESA (section 3.3, Threats Criteria). The threats criteria define the conditions under which NMFS can determine that responsible parties have addressed or mitigated the listing factors or threats. Together these make up the "objective, measurable criteria" required under section 4(f)(1)(B). This chapter discusses both kinds of criteria.

3.1 Recovery Goals

The primary goal of this plan is for the White Salmon River salmon and steelhead populations to contribute to the delisting of the LCR ESUs and the MCR Steelhead DPS. McElhany et al. (2000) defines a VSP as an independent population that has negligible risk of extinction over a 100-year timeframe. However, all populations within an ESU or DPS do not have to reach viable status for NMFS to delist the ESU/DPS (section 3.2.2, DPS and MPG Viability Criteria).

The visions, goals, and actions of many of the parties involved in the White Salmon recovery planning process may go beyond ESA delisting. The vision for broad-sense recovery incorporates ESA delisting goals in the sense that NMFS could delist White Salmon River salmon and steelhead during an extended and stepwise process of achieving broad-sense recovery goals. Broad-sense recovery goals incorporate many of the local and traditional uses, including those associated with rural and Native American values, which are important in the Pacific Northwest.

The proposed local, collaborative recovery board may choose to define additional, broad-sense goals for the White Salmon River watershed and other areas within the Washington Gorge Management Unit. The board's broad-sense goals for the area would likely build upon direction already adopted by various stakeholders in the area. These goals would then

guide the board as it defines and implements future recovery actions for the White Salmon River watershed.

3.2 Biological Viability Criteria

One of the main tasks assigned to the TRTs was to develop biologically based criteria for determining the viability of ESA listed salmon and steelhead. Viability criteria identify characteristics and conditions that, when met, describe viable populations and a viable ESU or DPS.

The TRTs based their approaches to recovery on guidance from the NMFS Technical Memorandum *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). This memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels. VSP guidelines provided by McElhany et al. (2000) recommend that a viable DPS population should be large enough to:

- Have a high probability of surviving variation observed in the past and expected future
- Be resilient to environmental and anthropogenic disturbances
- Maintain genetic diversity
- Support/provide ecosystem functions

NMFS organized the viability guidelines provided by McElhany et al. (2000 around four major considerations: abundance, productivity, spatial structure, and diversity. ESU/DPS-level viability criteria consider the appropriate distribution and characteristics of component populations to maintain the ESU/DPS in the face of longer-term ecological and evolutionary processes (ICTRT 2005a). The viability criteria defined by the ICTRT and W/LC TRT have been adopted as the biological criteria for delisting of the ESUs and DPS that include the listed White Salmon populations discussed in this Plan.

3.2.1 ESU/DPS Viability Criteria

Defining ESU and DPS Structure

The TRTs applied overall ESU/DPS-level viability criteria based on smaller units of MPG and independent populations to determine paths toward viability. Central to this approach is the recognition that salmonid population structure is hierarchical. The TRT based the biological criteria for populations and ESU/DPS-level viability on the existence of a biological hierarchy that spans ESUs/DPSs, major groupings, populations, and substructure within populations (Figure 3-1). The approach recognizes that historical salmonid populations within an ESU or DPS retain some genetic similarities because they move between different habitats during their life cycle. This distribution across the landscape and the diverse genetic, life history and morphological characteristics that evolve/contribute significantly to a population's long-term persistence.

- **Evolutionarily Significant Unit:** Two criteria define an ESU or DPS listed under the ESA: 1) it must be substantially reproductively isolated from other conspecific units, 2) it must represent an important component of the evolutionary legacy of the species (Waples 1991).
- **Major Population Grouping:** A group of populations that share similar genetic, geographic (hydrographic), and/or habitat characteristics within an ESU/DPS (ICTRT 2005b). The ICTRT termed this level in the hierarchy a MPG, and the W/LC TRT called it a "stratum." The TRTs consider MPGs, strata, and the "geographic regions" described by the Puget Sound TRT to be analogous.
- **Independent Population:** McElhany et al. (2000) defined an independent population as "…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. Groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame."

Hierarchy in Salmonid Population Structure

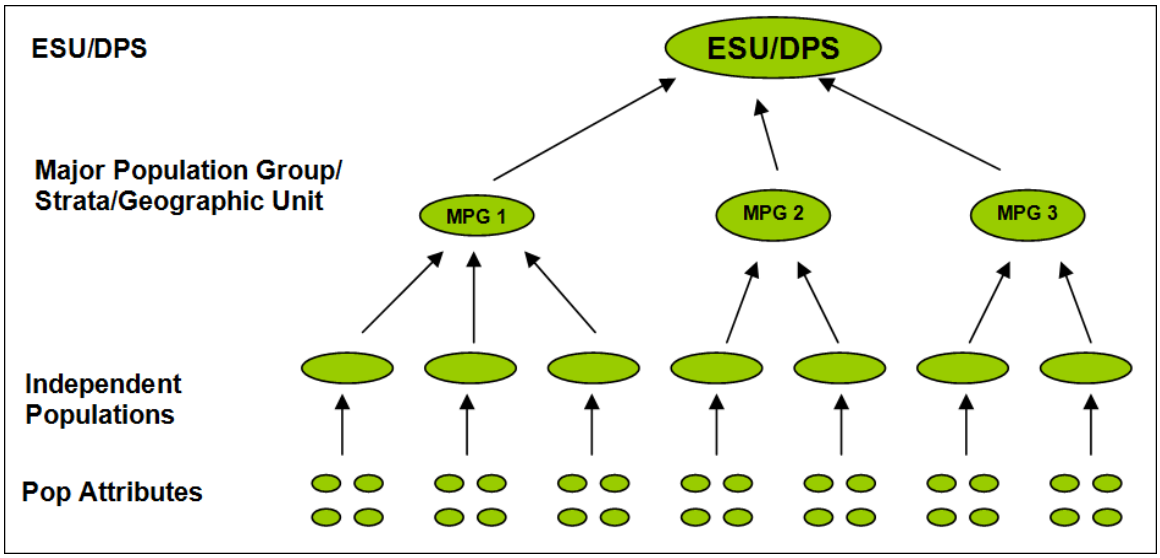


Figure 3-1. Hierarchical levels of salmonid population structure as defined by the TRTs for ESU/DPS recovery planning

The TRTs established ESU/DPS-level viability criteria based on the VSP guidelines identified by McElhany et al. (2000). The W/LC TRT identified five essential elements to address in its approach (McElhany et al. 2006). The ICTRT (2007) adapted these five elements for the middle Columbia Steelhead DPS. The five elements are:

Stratified Approach: Life history and ecological complexity that historically existed should have a high probability of persistence. The W/LC TRT aggregated populations into MPG, or strata, based on each combination of life history type and ecological zone. The ICTRT stratified the MCR steelhead DPS into groups based on ecoregion characteristics (Eastern Cascades, Columbia Plateau, John Day and Yakima), life history types (summer, winter and summer/winter) and other geographic and genetic considerations.

Viable Populations: Some individual populations within a MPG should have persistence probabilities consistent with a high probability of MPG persistence. The W/LC TRT defined high persistence probability based on the presence of at least two populations with a negligible risk of extinction and a strata average of a medium-low risk of extinction. The ICTRT defined high persistence probability based on the presence of at least two or one-half of historical populations with a negligible risk of extinction.

Representative Populations: Representative populations must achieve criteria or maintain viability criteria, but not every historical population needs to meet viability criteria. Viable combinations of populations should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and dispersed populations that minimize susceptibility to catastrophic events.

Non-deterioration: No population should be allowed to deteriorate until ESU/DPS recovery is assured, and all extant populations should be maintained. Current populations and population segments should be preserved. Recovery measures will be needed in most areas to arrest declining status and offset the effects of future impacts.

Safety Factors: Higher levels of recovery should be attempted in more populations than the minimum needed to achieve ESU/DPS viability because not all attempts will be successful. Recovery efforts should target more than the minimum number of populations and more than the minimum population levels thought to ensure viability. Some populations should be highly viable.

W/LC TRT Recommended Viability Criteria

The W/LC TRT document*, Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids* (McElhany et al. 2003) describes recommended viability criteria for salmon ESUs in the W/LC recovery domain. The LCFRB applied these 2003 criteria to assess viability and develop the recovery direction for the listed White Salmon River Chinook salmon, coho, and chum salmon populations that NMFS and the NPCC adopted as part of the lower Columbia Salmon Recovery and Subbasin Plan (LCFRB 2004). This direction is also included in this recovery plan. Summarized below are the criteria and approach defined by the W/LC TRT in 2003. In 2006, the W/LC TRT (McElhany et al. 2006) revised the 2003 criteria by incorporating new analyses by the W/LC TRT itself, other TRTs and state agencies, among others. The LCFRB and the WAGIT which includes White

Salmon stakeholders will eventually use the new criteria to update goals and status evaluations for Washington populations through the recovery plan revision process. The 2006 revised viability criteria (McElhany et al. 2006) are available at http://www.nwfsc.noaa.gov/trt/wlc/viability_report_revised.cfm (accessed April 11, 2012).

Independent Population Viability Criteria

The W/LC TRT's 2003 viability criteria (McElhany et al. 2003) use five population-level attributes as indicators for viability: 1) adult productivity and abundance, 2) juvenile out-migrant productivity, 3) population diversity, 4) habitat, 5) spatial structure. The 2003 report also provides a set of guidelines for examining viability for each indicator (McElhany et al. 2003). Shown in Table 3-1 are the 2003 viability criteria.

Table 3-1. Population viability criteria (McElhany et al. 2003; McElhany et al. 2006)

Adult Population Productivity and Abundance

1. In general, viable populations should demonstrate a combination of population growth rate, productivity, and abundance that produces an acceptable probability of population persistence. Various approaches for evaluating population productivity and abundance combinations may be acceptable, but must meet reasonable standards of statistical rigor.
2. A population with a non negative growth rate and an average abundance approximately equivalent to estimated historical average abundance is in the highest persistence category. The estimate of historical abundance should be credible, the estimate of current abundance should be averaged over several generations, and the growth rate should be estimated with adequate statistical confidence. This criterion takes precedence over criteria 1.

Juvenile Outmigrant Production

The abundance of naturally produced juvenile migrants should be stable or increasing as measured by observing a median annual growth rate or trend with an acceptable level of confidence.

Within Population Spatial Structure

The spatial structure of a population must support the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes. The metrics and benchmarks for evaluating the adequacy of a population's spatial structure should specifically address:

a. Quantity: Spatial structure should be large enough to support growth and abundance, and diversity criteria.

b. Quality: Underlying habitat spatial structure should be within specified habitat quality limits for life history activities (spawning, rearing, migration, or a combination) taking place within the patches.

c. Connectivity: Spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning, rearing, and migration patches.

d. Dynamics: The spatial structure should not deteriorate in its ability to support the population. The processes creating spatial structure are dynamic, so structure will be created and destroyed, but the rate of flux should not exceed the rate of creation over time.

e. Catastrophic Risk: The spatial structure should be geographically distributed in such a way as to minimize the probability of a significant portion of the structure being lost because of a single catastrophic event, either anthropogenic or natural.

Within Population Diversity

1. Sufficient life history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include:

    a. Substantial proportion of the diversity of a life-history trait(s) that existed historically,

    b. Gene flow and genetic diversity should be similar to historical (natural) levels and origins,

    c. Successful utilization of habitats throughout the range, and

    d. Resilience and adaptation to environmental fluctuations.

General Habitat

1. The spatial distribution and productive capacity of freshwater, estuarine, and marine habitats should be sufficient to maintain viable populations identified for recovery.

2. The diversity of habitats for recovered populations should resemble historical conditions given expected natural disturbance regimes (e.g., wildfire, flood, volcanic eruptions, etc.). Historical conditions represent a reasonable template for a viable population; the closer the habitat resembles the historical diversity, the greater the confidence in its ability to support viable populations.

At a large scale, habitats should be protected and restored, with a trend toward an appropriate range of attributes for salmonid viability. Freshwater, estuarine, and marine habitat attributes should be maintained in a non-deteriorating state.

The W/LC TRT's revised criteria, described in their 2006 report *Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins* (McElhany et al. 2006), use three population-level attributes as indicators of viability instead of the five identified in 2003. The 2006 attributes are: 1) abundance and productivity, 2) spatial structure, 3) diversity. The revised criteria include juvenile out migrant productivity as a subset of abundance and productivity and address habitat criteria as part of the discussion of listing factors criteria (McElhany et al. 2006).

The W/LC TRT's 2003 system for integrating population attributes to assess population extinction risk used a 0-4 qualitative scale, with zero indicating a population with a low probability of persistence, and four indicating a population with high probability of persistence. The TRT's 2006 report (McElhany et al. 2006) maintains this system (Table 3-2).

Table 3-2. Population persistence*/viability categories (McElhany et al. 2003; McElhany et al. 2006)

Scale	*Viability*	*Description*	*Persistence Probability**
0	Very Low (VL)	Either extinct or very high risk of extinction	0-40%
1	Low (L)	Relatively high risk of extinction	40-74%
2	Medium (M)	Medium high risk of extinction	75-94%
3	High (H)	Low (negligible) risk of extinction (represents a "viable" level)	95-99%
4	Very High (VH)	Very low risk of extinction	>99%

** 100-year persistence probabilities*

Strata and ESU Viability Criteria

The criteria developed by the W/LC TRT for recovery planning in 2003 state that for an ESU as whole to be viable, all of the historical strata need to have a high probability of persistence (McElhany et al. 2003). The W/LC TRT used ratings of individual population's extinction risk to determine viability at the strata and ESU levels. Table 3-3 shows criteria guidelines identified by the W/LC TRT to complete these evaluations. The TRT maintained its support for the guidelines in its 2006 report (McElhany et al. 2006).

Table 3-3. Criteria guidelines for determining strata and ESU viability (McElhany et al. 2003, 2006)

ESU-Level Criteria Guidelines
1. Every Stratum (life history and ecological zone combination) that historically existed should have a high probability of persistence
Strata-Level Criteria Guidelines
1. Individual populations within a stratum should have persistence probabilities consistent with a high probability of strata persistence 2. Within a stratum, the populations restored/maintained at viable status or above should be selected to: a. Allow for normative metapopulation process, including the viability of "core" populations that are defined as the historically most productive populations b. Allow for normative evolutionary processes, including the retention of the genetic diversity represented in relatively unmodified historic gene pools c. Minimize susceptibility to catastrophic events
ESU-Level Recovery Strategy Criteria Guidelines
1. Until all ESU viability criteria have been achieved, no population should be allowed to deteriorate in its probability of persistence 2. High levels of recovery should be attempted in more populations than identified in the strata viability criteria because not all attempts will be successful

ICTRT Recommended Biological Viability Criteria

The ICTRT developed biologically based viability criteria for ESA-listed salmon and steelhead in the Interior Columbia domain. The ICTRT based its approach to recovery on guidance from the NMFS Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). As stated above, this memorandum provides general direction for setting viability objectives at the ESU/DPS and component population levels.

Viability criteria at the population level address four VSP parameters (McElhany et al. 2000):

- *Abundance* - the average number of spawners in a population over a generation or more
- *Productivity* - the performance of a population over time in terms of recruits produced per spawner
- *Spatial Structure* - a population's geographic distribution and the processes that affect that distribution
- *Diversity* - the distribution of genetic, life history, and phenotypic variation within and among populations

The ICTRT grouped specific population-level criteria into two categories to assess viability at the independent population level: measures addressing abundance and productivity, and measures addressing spatial structure and diversity. The viability of an independent population is determined by integrating risks across the four parameters.

The ICTRT's objective for population abundance and productivity is that abundance should be high enough that 1) in combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent historical patterns of environmental variability; 2) compensatory processes provide resilience to the effects of short-term perturbations; 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns) (ICTRT 2005a).

The ICTRT developed criteria for characterizing the relative size and complexity of Interior Columbia Basin steelhead populations based on their analysis of the intrinsic or historical potential habitat available to the population (ICTRT 2005a). This analysis used available Geographic Information System (GIS) data layers showing stream characteristics (e.g. channel width, gradient, and valley confinement) and empirically derived relationships between habitat type, stream structure, landscape processes, and spawning. The ICTRT built a model that also incorporated information from local biologists and recovery planners to identify natural barriers to migration and other local variations.

Mid-Columbia steelhead spawn in a wide range of tributary drainage areas: from small creeks such as Fifteenmile or Rock Creek to very large rivers such as the lower John Day. The ICTRT categorized historical population sizes as Basic, Intermediate, Large, and Very Large, and set minimum abundance thresholds for steelhead populations of each type as follows: Basic: 500 spawners; Intermediate, 1,000 spawners; Large, 1,500 spawners; Very Large, 2,250. The abundance thresholds are associated with minimum productivity thresholds, based on modeling studies described by the ICTRT (March 2007a and November 2007b). Modeling studies link abundance and productivity, within limits: above a certain threshold, higher productivity can compensate for lower abundance and vice versa.

The ICTRT used the concept of the viability curve (ICTRT 2007a, 2007b; McElhany et al. 2006) as a framework for defining population specific abundance and productivity levels to meet the objectives (Figure 3-2). A viability curve describes combinations of abundance and productivity that yield a particular risk threshold. The viability curve links the two parameters relative to extinction risks associated with short-term environmental variability. Given a particular productivity level, larger populations are more resilient in the face of year-to-year variability in overall survival rates than are smaller populations. Populations with relatively high intrinsic productivity (expected ratio of spawners to their parent spawners at low levels of abundance) are also more robust at a given level of abundance than populations with lower intrinsic productivity.

The ICTRT generated viability curves for each population to define the combinations of abundance and productivity corresponding to a range of extinction risks over a 100-year period - less than 1 percent (very low), less than 5 percent (low), less than 25 percent (moderate), and greater than 25 percent (high), see Figure 3-2. It targeted population level recovery strategies to achieve less than a 5 percent (low) risk of extinction in a 100-year period. This is consistent with the VSP guidelines and conservation literature (McElhany et al. 2000; NRC 1995).

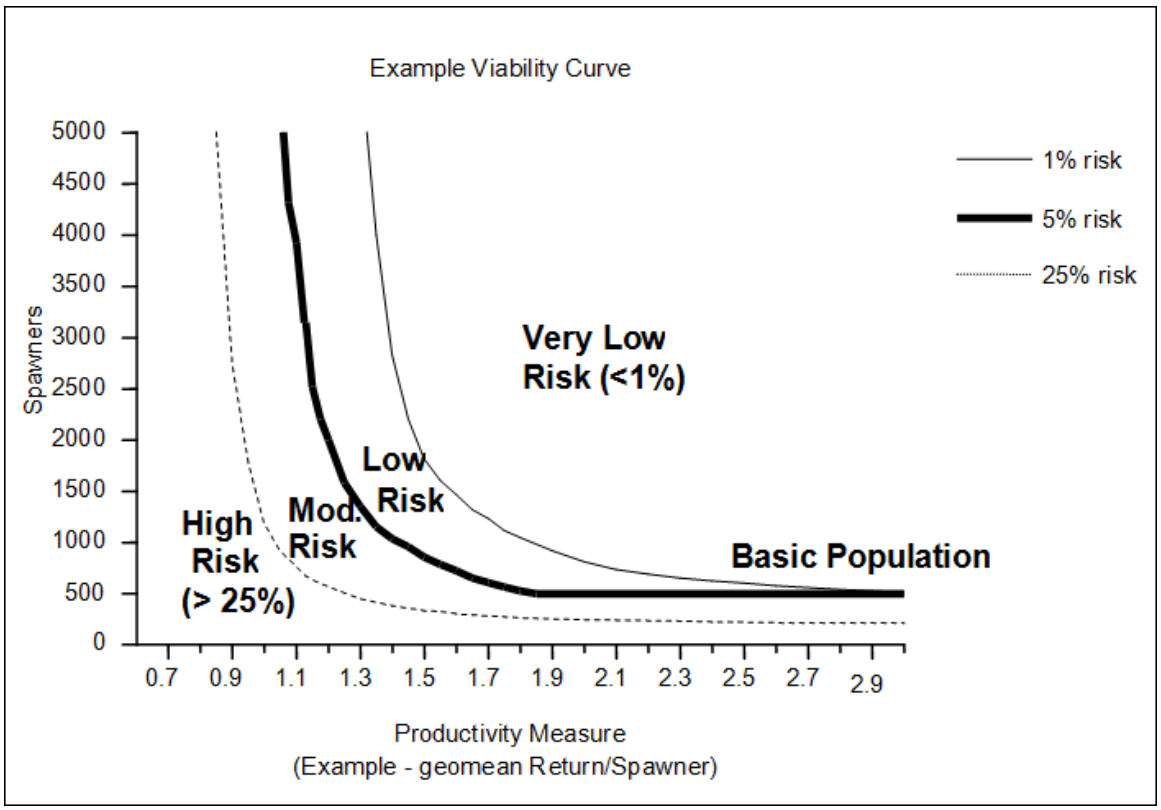


Figure 3-2. Example of an abundance/productivity viability curve (ICTRT 2007a)

3.2.2 DPS and MPG Viability Criteria

Similar to the W/LCR TRT approach to strata and ESU viability criteria (Table 3-3) the ICTRT (2007) developed criteria based on recovery of MPGs. MPGs are geographically and genetically cohesive population groups, and are critical components of ESU/DPS spatial structure and diversity (Figure 2-10). Having all MPGs within an ESU/DPS at low risk provides the greatest probability of persistence for the ESU/DPS. Thus, the ICTRT criterion for a viable ESU/DPS is that all extant MPGs and any extirpated MPGs critical for proper functioning of the ESU/DPS should be at low risk.

Further, the following five criteria should be met for an MPG to be regarded as at low risk (viable) (ICTRT 2007b):

1. At least one-half of the populations historically within the MPG (with a minimum of two populations) should meet viability standards.
2. At least one population should be classified as “Highly Viable.”
3. Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as “Very Large," "Large," or “Intermediate,” generally reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.

4. All major life history strategies (e.g., spring and summer-run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.
5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and preserve options for ESU/DPS recovery.

Population Recovery Classifications

The W/LC TRT and LCFRB used the results of the 2003 Population Viability Criteria report to build a recovery scenario that describes the target status for each population. The W/LC TRT and the LCFRB classified individual populations as *primary* (targeted for restoration to high or high + probability of persistence), *contributing* (targeted for restoration to low or medium probability of persistence), or *stabilizing* (populations that are to be maintained at current levels and likely to have low probabilities of persistence). They identified the following target levels for White Salmon Chinook salmon, coho, and chum salmon. The LCFRB has updated the 2004 recovery plan and proposed to maintain the classifications for all of the White Salmon River populations except coho salmon, which has been elevated to a primary population classification (LCFRB 2010).

White Salmon River Fall Chinook salmon (Contributing, Medium)

Historically, the tule fall Chinook salmon population in the White Salmon was large. Condit Dam affected the population, although a small amount of fall Chinook salmon habitat was available downstream of the dam and upstream from Bonneville Reservoir inundation. The Spring Creek Hatchery program, which originated from White Salmon River fall Chinook salmon stock, is located three miles downstream of the river mouth and straying of returning hatchery adults to the White Salmon River is consistent with a *contributing* population designation. A tribal fishery targets Spring Creek Hatchery fish near the river mouth. The W/LC TRT and the LCFRB targeted the White Salmon population for medium viability to reflect concerns with hydro impacts (Bonneville and Condit dams) and higher harvest rates associated with combined treaty and non-treaty fisheries. Based on the TRT's findings, the Plan proposed an abundance goal for recovery of 900 fish (LCFRB 2004).

White Salmon River Spring Chinook salmon (Contributing, Low)

This population was historically significant but is currently extinct. Reintroduction would include use of an outside stock. The best source stock may be from the Klickitat, which is outside the lower Columbia ESU. The W/LC TRT would need to provide criteria for evaluating appropriate source stocks for reintroduction. The low viability target for White Salmon spring Chinook salmon recognizes the long period required to restore a locally adapted natural population from an out-of-basin stock. Based on TRT findings, the Plan proposed an abundance goal for recovery of 400 fish (LCFRB 2004).

White Salmon River coho salmon (Primary, High)

The White Salmon River coho salmon are part of the Washington upper Gorge Tributaries and White Salmon River population. Lack of access to habitats upstream of Condit Dam

limits current potential for coho salmon production in the White Salmon River. There may be some coho salmon production occurring in the one-mile reach downstream of Condit Dam. Based on TRT findings, the Plan proposed an abundance goal for recovery of 150 fish (LCFRB 2004).

Upper Gorge chum salmon, including White Salmon River chum salmon (Contributing, Medium)

The LCFRB identified the entire population of upper Gorge chum salmon to have a very low viability (LCFRB 2004). Bonneville Reservoir inundates most of historical habitat for this population and passage at Bonneville Dam impacts both juvenile and adult migration. The LCFRB proposed an abundance goal for recovery of 600 fish.

White Salmon River steelhead (Low Risk)

The ICTRT did not apply the same classification system to MCR steelhead populations but did identify that to be viable, the White Salmon steelhead population needs to reach a minimum abundance threshold of 500 naturally produced spawners with a sufficient intrinsic productivity to achieve a five percent or less risk of extinction over a 100-year timeframe (ICTRT 2007b). The ICTRT recognizes that recovering this functionally extirpated population to a viable level may not be necessary to achieve viability at the MPG and DPS levels.

3.3 Threats Criteria

NMFS evaluated listing factors under section 4(a)(1) when the agency made the initial determination to list the species for protection under the ESA. In the future, when NMFS reevaluates the status of the species to determine whether these factors continue to limit recovery, the agency can decide whether the protections of the ESA are still warranted. If no longer warranted, NMFS could delist the species.

At the time of a delisting decision, NMFS will examine whether the entities responsible for recovery have addressed the section 4(a)(1) listing factors. To assist in this examination, NMFS will use the listing factors (or threats) criteria described below in addition to evaluation of biological recovery criteria and other relevant data and policy considerations.

To determine that the affected DPS has recovered to the point that it no longer requires the protections of the ESA, NMFS will review the status of the listing factors according to the specific criteria identified for each of them (see below). The threats need to have been addressed to the point that delisting is not likely to result in their re-emergence. It is possible that current perceived threats will become insignificant in the future as a result of changes in the natural environment or changes in the way threats affect the entire life cycle of salmon. Consequently, as the result of RM&E, NMFS expects that the agency will change the ranking of threats over time and identify new threats. During the 5-year status reviews, NMFS will evaluate and review the listing factor criteria under conditions at the time.

The specific criteria listed below for each of the relevant listing/delisting factors help to ensure that responsible entities address and mitigate the underlying causes of prior to considering a species for delisting. NMFS expects that if the proposed actions described in

the Plan are implemented, they will make substantial progress toward meeting the following listing factor (threats) criteria:

Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range

To determine that the ESU or DPS is recovered, threats to habitat should be addressed to a degree sufficient to support a viable ESU or DPS as outlined below:

1. Impaired fish passage (e.g., dams and culverts) is addressed, either through removal or modification of obstructions, to improve survival and restore access to historically accessible habitat where necessary to support recovery goals.
2. Flow conditions that support sufficient salmonid rearing, spawning, and migration of a viable ESU or DPS are achieved, where possible, through management of White Salmon River mainstem and tributary irrigation operations, and through the improvement of other water user efficiencies and conservation, including for municipal supply and other consumptive purposes.
3. Forest management practices that protect watershed and stream functions are implemented on Federal, state, tribal, and private lands.
4. Agricultural best management practices, including grazing, are implemented to protect and restore riparian areas, floodplains, and stream channels, and to protect water quality from sediment, pesticide, herbicide, and fertilizer runoff.
5. Urban and rural development, including land use conversion from agriculture and forestland to residential uses, avoids impairment of water quality or impairment of natural stream conditions.
6. The effects of toxic contaminants on salmonid fitness and survival in the White Salmon mainstem and tributaries are sufficiently limited so as not to affect recovery.
7. Channel function, including vegetated riparian areas, canopy cover, streambank stability, off-channel and side-channel habitats, natural substrate and sediment processes, and channel complexity, is restored to provide adequate rearing and spawning habitat.
8. Floodplain function and the availability of floodplain habitats for salmon are restored to a degree sufficient to support a viable ESU/DPS. This restoration should include connectivity between river and floodplain and the restoration of altered sediment routing.
9. Water operations management in the mainstem White Salmon and tributaries maximize survival of juvenile rearing, emigrating smolts, and immigrating and spawning adults.

Factor B: Over-utilization for commercial, recreational, scientific or educational purposes

To determine that the ESU or DPS is recovered, any utilization for commercial, recreational, scientific, or educational purposes should be managed as outlined below:

1. Fishery management plans for salmon are in place that (a) accurately account for total fishery mortality (i.e., both landed catch and non-landed mortalities) and constrain mortality rates to levels that are consistent with achieving population viability (i.e., provide for adequate spawning escapement given their productivity); (b) are implemented in such a way as to avoid deleterious genetic effects on populations or negatively affect the distribution of populations.
2. Federal, state, and tribal fishing rules and regulations are effectively enforced.
3. Technical tools accurately assess the effects of the harvest regimes so that harvest objectives are met but not exceeded.
4. Scientific handling of fish from adult and juvenile trapping operations is minimized to reduce indirect mortalities associated with education or scientific programs, while recognizing that monitoring, research, and education are key actions for conservation of the species.
5. To the degree sufficient to support a viable ESU or DPS, routine instream construction and maintenance practices are implemented in a manner to reduce or eliminate mortality of listed species.

Factor C: Disease or predation

To determine that the DPS is recovered, any disease or predation that threatens its continued existence should be addressed as outlined below:

1. Hatchery operations do not subject salmon populations to deleterious diseases and parasites and do not result in increased predation rates of wild salmon.
2. Predation by avian predators is managed in a way that promotes recovery of salmon populations.
3. The northern pike minnow are managed to reduce predation on salmon to a degree sufficient to meet recovery goals.
4. Populations of introduced smallmouth bass, walleye, and catfish are managed such that competition or predation does not impede salmon recovery. Predation by marine mammals on salmon runs below Bonneville Dam is managed within the framework of applicable statutes and to the degree necessary to protect upstream migration of salmon.
5. Physiological stress and physical injury that may cause disease or increase susceptibility to pathogens during rearing or migration should be reduced during critical low flow periods (e.g., low water years) or poor passage conditions (e.g., at diversion dams or bypasses).

Factor D: The inadequacy of existing regulatory mechanisms

To determine that the ESU or DPS is recovered, any inadequacy of existing regulatory mechanisms that threatens its continued existence should be addressed to the degree necessary to support a viable ESU or DPS, as outlined below:

1. Sufficient resources, priorities, regulatory frameworks, and coordination mechanisms are established and/or maintained for effective enforcement of land and water use regulations that protect and restore habitats and for the effective management of fisheries.
2. Habitat conditions and watershed functions are protected through land-use planning that guides human population growth and development.
3. Habitat conditions and watershed function are protected through regulations that govern resource extraction such as timber harvest and gravel mining.
4. Habitat conditions and watershed functions are protected through land protection agreements as appropriate and where existing policy or regulations do not provide adequate protection.
5. Regulatory, control, and education measures to prevent additional exotic plant and animal species invasions are in place.

Factor E: Other natural or human-made factors affecting its continued existence

To determine that the ESU or DPS is recovered, other natural and human-made threats to its continued existence should be addressed as outlined below:

1. Hatchery programs are being operated in a manner that is consistent with individual watershed and region-wide recovery approaches, recognizing Federal obligations; appropriate criteria should be used for the integration, where appropriate, of hatchery populations and extant natural populations inhabiting watersheds where the hatchery fish return.
2. Hatcheries operate using appropriate ecological, genetic, and demographic risk containment measures for: (1) hatchery-origin adults returning to natural spawning areas, (2) release of hatchery juveniles, (3) handling of natural-origin adults at hatchery facilities, (4) withdrawal of water for hatchery use, (5) discharge of hatchery effluent, (6) maintenance of fish health during their propagation in the hatchery.
3. Mechanisms are in place to effectively continue monitoring the proportion of hatchery and wild spawners in the watershed.
4. Mechanisms are in place to reduce the incidence of, and impacts from, introduced, invasive, or exotic plant and animal species.
5. Nutrient enrichment programs should be evaluated to determine where additional nutrient inputs can provide significant benefits.

4 Current Status Assessment

In 2004, the W/LC TRT completed a population extinction risk evaluation of salmon and steelhead populations in the Willamette and LCR Basins, including White Salmon River populations (McElhany et al. 2004). During the evaluation, biologists ranked each population for absolute extinction risk on a scale of 0 to 4, with 0 = extirpation or nearly so, and 4 = very low extinction risk (McElhany et al. 2003). Each member of the W/LC TRT, based on the information available, ranked the VSP attributes such that the score for each attribute added up to 10, and then they provided an estimate of "data quality" based on their assessment of the overall amount of information available for each attribute (McElhany et al. 2004). Discussed below are the results of this evaluation.

4.1 Risk of Extinction: Willamette/Lower Columbia TRT

White Salmon River Fall Chinook salmon

White Salmon River fall-run Chinook salmon received a weighted average score of 0.86, suggesting that the population is at a very high risk of extinction (Table 4-1). In their review, W/LC TRT members recognized the population's low total abundance, some team members commented that the population is extirpated from its historical range, except for 2 to 2.5-mile reach below Condit Dam, and that the overwhelming majority of fish observed in the river are strays from nearby hatcheries. Other members considered the observed adults as *de facto* population members (McElhany et al. 2004). Overall, most TRT members considered the in-river fall-run Chinook salmon population to be heavily influenced by hatchery strays, although some members included the Spring Creek NFH in their diversity evaluation as a potential source for re-establishing a native-run.

Table 4-1. Evaluation scores for White Salmon fall-run Chinook salmon (McElhany et al. 2004)

*Attribute**	*0.00*	*1.00*	*2.00*	*3.00*	*4.00*	*Average*	*Data quality*
Productivity	3.17	4.67	2.17	0.00	0.00	0.90	1.83
Juvenile outmigrants				NR			
Diversity	2.00	3.33	3.83	0.83	0.00	1.35	2.00
Habitat	3.50	5.00	1.50	0.00	0.00	0.80	1.50
Spatial Structure	7.17	2.83	0.00	0.00	0.00	0.28	3.00

* W/LC TRT scores rated on a 0-4 scale: 0 = extirpated or nearly so, 1 = relatively high extinction risk, 3 = low extinction risk, and 4 = very low extinction risk. NR = not relevant

White Salmon River Spring Chinook salmon

McElhany et al. (2004) gave the White Salmon spring-run Chinook salmon a weighted average extinction risk score of 0.07, indicating the population is extirpated (Table 4-2). The team concluded that the population is extirpated from construction and over 90 years of blocked passage at Condit Dam. Some members included observed spring-run-timed spawners at the base of Condit Dam, while others considered these fish as strays spawning in unsuitable habitat for spring-run Chinook salmon (McElhany et al. 2004).

Table 4-2. Evaluation scores for White Salmon spring-run Chinook salmon (McElhany et al. 2004)

*Attribute**	*0.00*	*1.00*	*2.00*	*3.00*	*4.00*	*Average*	*Data quality*
Productivity	9.33	0.67	0.00	0.00	0.00	0.07	1.33
Juvenile outmigrants	10.00	NR	NR	NR	NR	NR	4.00
Diversity	8.33	1.33	0.33	0.00	0.00	0.20	1.50
Habitat	10.00	0.00	0.00	0.00	0.00	0.00	1.50
Habitat (w/o dams)	3.75	3.50	2.75	0.00	0.00	0.90	1.50
Spatial structure	9.67	0.33	0.00	0.00	0.00	0.03	3.17

* W/LC TRT scores rated on a 0-4 scale: 0 = extirpated or nearly so, 1 = relatively high extinction risk, 3 = low extinction risk, and 4 = very low extinction risk. NR = not relevant

White Salmon River coho salmon

White Salmon coho salmon received a weighted average extinction risk score of 0.39, indicating that the population is extirpated or nearly so (Table 4-3). TRT members, however, used a default score for no data, which assumes that fish may exist but are not monitored; other members noted that the White Salmon coho salmon population was probably extirpated following construction of Condit Dam, implying the default score might not be appropriate (McElhany et al. 2004). The TRT determined that hatchery introductions, the near absence of accessible spawning habitat, and the low probability of any successful natural reproduction suggest that most genetic diversity native to the White Salmon is extirpated and was replaced by hatchery introductions. In evaluating the habitat criterion, many TRT members included historical spawning habitat above the dam in their considerations (McElhany et al. 2004).

Table 4-3. Evaluation scores for White Salmon coho salmon (McElhany et al. 2004)

Attribute*	**0.00**	**1.00**	**2.00**	**3.00**	**4.00**	**Average**	**Data quality**
Productivity	5.00	5.00	0.00	0.00	0.00	0.50	0.17
Juvenile outmigrants	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diversity	7.83	2.17	0.00	0.00	0.00	0.22	1.50
Habitat	5.33	3.67	1.00	0.00	0.00	0.57	2.00
Spatial structure	9.17	0.83	0.00	0.00	0.00	0.08	1.83

* W/LC TRT scores rated on a 0-4 scale: 0 = extirpated or nearly so, 1 = relatively high extinction risk, 3 = low extinction risk, and 4 = very low extinction risk.

Upper Gorge Tributaries chum salmon

Upper Gorge Tributaries chum salmon, including those that occupied the White Salmon historically, received a weighted average extinction risk score of 0.18, indicating that the population is extirpated or nearly so (Table 4-4). Data are limited to Bonneville Dam passage counts, although many fish that ascend fall back to spawning areas below the dam. Fish technicians have recovered only a few carcasses above Bonneville Dam; no one has reported spawning aggregations, although biologist M. Weeber, (Weeber, M. personal communication, Oregon Department of Fish and Wildlife (ODFW), 2010), observed individual spawners in Eagle Creek, Oregon. The Bonneville Pool eliminated spawning habitat in both the mainstem and lower creek reaches, creating a series of disconnected spawning sites and culverts, and, stream modifications on the transit corridor on the Washington side of the CR may limit access for a few chum salmon that may be present. Low abundance for the species as a whole may also restrict population dispersal (McElhany et al. 2004).

Table 4-4. Evaluation scores for upper Gorge chum salmon (McElhany et al. 2004).

Attribute*	0.00	1.00	2.00	3.00	4.00	Average	Data quality
Productivity	9.50	0.50	0.00	0.00	0.00	0.05	1.00
Juvenile outmigrants	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diversity	8.67	1.33	0.00	0.00	0.00	0.13	1.17
Habitat	6.67	2.67	0.50	0.17	0.00	0.42	1.83
Spatial structure	7.33	1.83	0.67	0.17	0.00	0.37	1.83

* W/LC TRT scores rated on a 0-4 scale: 0 = extirpated or nearly so, 1 = relatively high extinction risk, 3 = low extinction risk, and 4 = very low extinction risk.

4.2 Extinction Risk: Interior Columbia TRT

White Salmon River Steelhead

Scientists consider the White Salmon River steelhead population functionally extirpated. The abundance of native summer and winter steelhead in the White Salmon River before 1919, when the loss of the fish ladder at Condit Dam blocked passage to upriver spawning and rearing grounds is unknown. However, some natural steelhead production in the reach below Condit Dam continued to occur (Bambrick et al. 2004). Some biologists believe that residual steelhead populations in the form of resident trout may contribute to anadromy in the watershed. *O. mykiss* from Rattlesnake Creek have been observed showing physiological changes consistent with smoltification, and fish have been detected outmigrating during the typical smolt migration period (B. Allen, personal communication, 2007). As further evidence in support of the retention of anadromous life history traits, a PIT-tagged *O. mykiss* was detected outmigrating from lower Rattlesnake Creek in March 2005, and was detected again in July 2006 moving up through the adult fish ladder at Bonneville Dam, possibly as a

one-salt steelhead (B. Allen, personal communication, 2007). Even with this observation, remnant genetic influences from the original White Salmon River steelhead population in fish spawning in the small section of the White Salmon River below Condit Dam is thought to be minor with natural production coming primarily from the large releases of out-of-basin hatchery stock.

Biologists generally believe that White Salmon River steelhead historically ranged from the mouth to RM 16.3 in the mainstem and into Buck, Spring, Indian, and Rattlesnake creeks (Figure 4-12) (ICTRT 2008). Some anecdotal historic records (WDF 1951), suggest that anadromous fish may have once ascended the White Salmon River as far as Trout Lake, RM 28.2. Most biologists, however, consider Big Brother Falls, RM 16.2, to be the upper limit of historical steelhead migration (NPCC 2004). This historical range provided approximately 33 to 40 miles of steelhead spawning and rearing habitat (NPCC 2004; Bambrick et al. 2004; Ecology 2007).

The ICTRT identified one MaSA, below Big Brother Falls, within the White Salmon watershed based on its historical intrinsic potential analysis. The ICTRT defines a MaSA as a system of one or more branches that contains sufficient habitat to support at least 500 spawners. The ICTRT does not consider any population fewer than 500 spawners to be viable, regardless of its intrinsic productivity.

Figure 4-1 shows the intrinsic habitat potential and MaSA for the White Salmon River summer/winter steelhead populations as identified by the ICTRT in their 2008 analysis (ICTRT 2008). Intrinsic potential is the estimated relative suitability of a habitat for spawning and rearing of anadromous salmonids species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

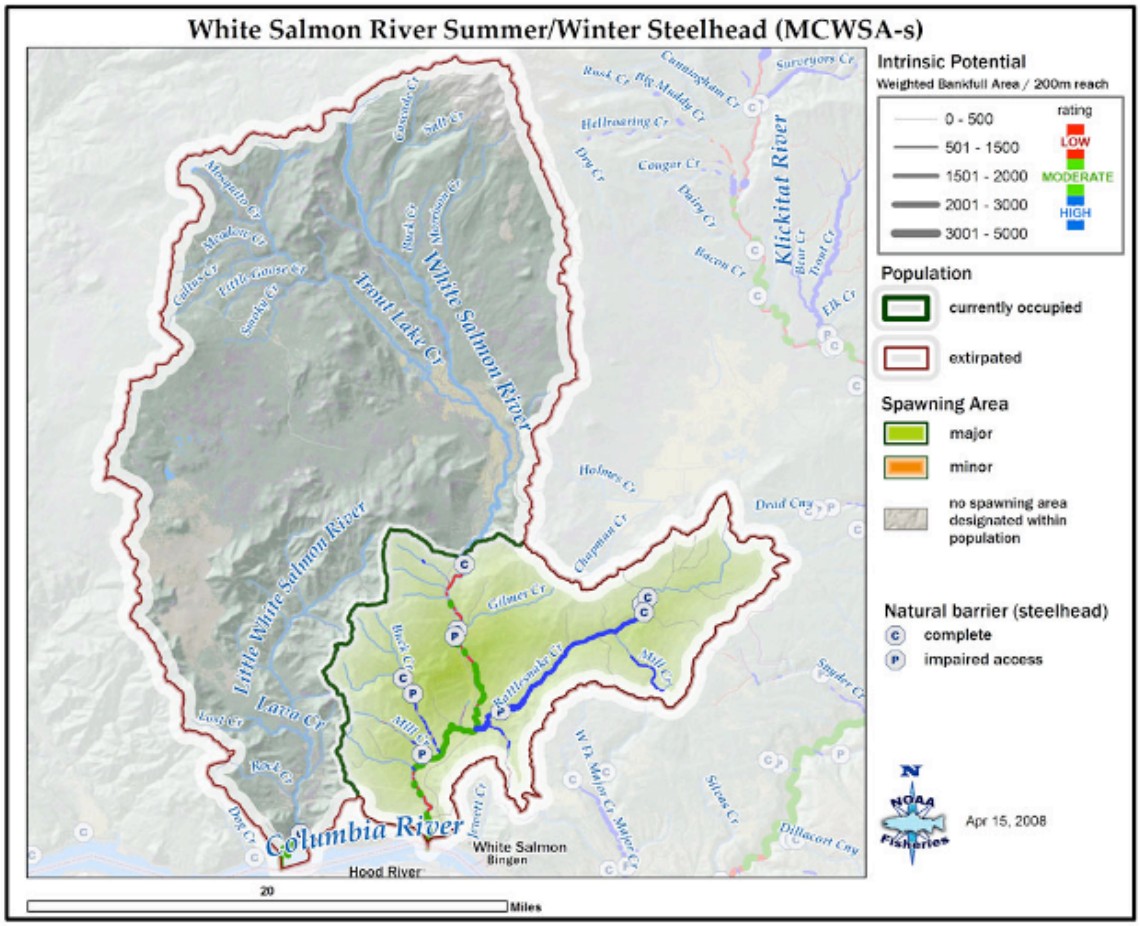


Figure 4-1. Intrinsic habitat potential and Major Spawning Area for the White Salmon River summer/winter steelhead (ICTRT 2008)

5 Limiting Factors and Threats

Scientists generally describe the reasons for a species' decline in terms of limiting factors and threats. Analysis of limiting factors and threats across the entire species' life cycle forms the basis for designing recovery strategies and actions. NMFS defines limiting factors as the biological and physical conditions limiting DPS and population status (e.g., elevated water temperature), and defines threats as those human activities or naturally induced actions that cause the limiting factors (e.g., removal of riparian vegetation for agricultural or residential purposes, which causes loss of shade and, consequently, elevated water temperature).

For salmon and steelhead, survival to reproduce depends on a complex, interacting system of environmental conditions, with different conditions needed for each life stage. Optimal water temperature, for example, varies (within limits) for adult migration versus egg incubation or juvenile rearing. Because of this complexity, in many cases, scientists have a poor understanding of the actual limiting factors.

The list of limiting factors for the White Salmon River salmon and steelhead populations, as for the other populations that make up the LCR salmon ESUs and the MCR steelhead DPS addressed in this recovery plan, is based on a substantial body of research on salmonids, local field data and field observations, and the considered opinions of regional experts. These are implicitly hypothetical statements, made with the expectation that by taking action in the face of some degree of scientific uncertainty, then monitoring the results, continuing to conduct research as a high priority, and adapting our management actions in response, the state of our knowledge will improve and so will fish survival, although not necessarily in a directly parallel process.

Until recently, the primary factor limiting production of all White Salmon species was the presence of Condit Dam. PacifiCorp breached the dam in October 2011, and has removed the structure. Now that the dam no longer serves as a barrier to upstream migration, the primary factor affecting recovery in the White Salmon River watershed is the lack of native stocks. Spring Chinook salmon, coho, chum salmon, and steelhead populations are either extirpated or functionally extirpated (Good et al. 2005, ICTRT 2007b, Ford et al. 2011). The development of local populations will necessitate natural re-colonization or require the introduction of stocks from other basins, but may be limited by the quality of habitat within the watershed.

Salmon and steelhead have not occupied the habitat upstream of the dam for decades. An abundance of unoccupied habitat is present in the basin. Therefore, habitat quality upstream of the former dam is not currently limiting the populations. Fall Chinook salmon and some strays of other species utilize the lower river below the former Condit Dam. The numbers of fall Chinook salmon spawners increased from low levels in the early 2000s (WDFW 2002) to an average of 2,750 for the 2007-08 period (Roler 2009). The majority of the fall Chinook salmon, spawning in the lower river, were assumed to be strays from Spring Creek NFH. The marking of all of the production at Spring Creek NFH has shown that the escapement in recent years has been overwhelmingly from natural-origin fall Chinook salmon (Roler 2011). Prior to breaching of the dam, the habitat in the lower river may have been limiting Chinook salmon production in the years of high abundance.

In the future, some of the species that historically occupied the watershed may slowly begin to occupy upstream habitat through natural re-colonization/straying. More direct stocking may also occur to facilitate the rate of population growth. As the populations recover, some factor related to in-river habitat, quality may eventually become the factor limiting salmonid production. To a certain degree, this will depend upon the species that come to occupy that habitat and also on the degree that the various natural waterfalls in the basin end up restricting dispersion of the species.

When the dam was breached, the reservoir drained quickly. Biologists have not yet had the opportunity to evaluate the current condition of habitat downstream of the dam, but they anticipate large amounts of sediment entering the lower river and moving into the Columbia River. They cannot predict, with any certainty, other habitat conditions after removal; however, the reduction of habitat carrying capacity of the habitat is likely to persist for some unknown period of time. Habitat downstream of the dam may limit population production in the lower river until that habitat recovers from the effects of the removal of the dam, though redds were observed in the lower river in 2012 (R. Engle, USFWS, personnel communication December 2012).

The discussion below further describes what biologists currently know about the condition of the basin's habitat. Numerous studies completed since 2002, including the applicable results of the EDT run completed in 2004 (Allen and Connolly 2005), form the basis of this habitat discussion. In that spirit, this chapter describes potential factors that may limit future anadromous salmon and steelhead populations in the White Salmon River watershed. Chapter 5 is organized as follows:

- Section 5.1 addresses the migration barrier at Condit Dam.
- Section 5.2 identifies freshwater life cycle factors.
- Section 5.3 describes effects on the populations from hatchery production and releases.
- Section 5.4 discusses impacts from harvest.
- Section 5.5 identifies effects from the CR hydrosystem.
- Section 5.6 discusses effects of predation.
- Section 5.7 discusses ocean effects.
- Section 5.8 discusses climate change.
- Section 5.9 discusses other large-scale threats.

5.1 Blocked Migration and Impaired Passage

The single greatest factor limiting salmon and steelhead populations in the White Salmon River watershed was the migration barrier at Condit Dam. Only a small percentage of the historical anadromous spawning and rearing areas was accessible. Table 5-1 presents the current or pre-Condit Dam removal and historical distribution (post Bonneville Dam) within the White Salmon River watershed based on the assumptions built into the EDT model. Note

that as an artifact of the EDT model, it defined fall and spring Chinook salmon spawning habitat with no overlap. As a result, the fall Chinook salmon habitat was reduced to cover an area less than what biologists generally believe to be historically accessible. Biologists have considered fall Chinook salmon habitat to have historically extended up to Husum Falls at RM 7.6, which may overlap with possible spring Chinook salmon spawning habitat between Condit Dam and Husum Falls. Chum salmon is the only species that would have access to all of its remaining historical range with the dam in place.

Table 5-2 summarizes primary limiting factors for LCR fall Chinook salmon. Table 5-3 summarizes additional limiting factors affecting anadromous fish in the White Salmon River Basin. Described below are these limiting factors.

Table 5-1. River miles of salmon and steelhead habitat above and below Condit Dam (NPCC 2004).

Species	*Historical Distribution*	*Current Distribution*	*% of Historical Access*	*Comments*
Chum salmon	1.2 miles	1.2 miles	20%	80 percent of spawning area flooded by Bonneville Dam
Fall Chinook salmon	3.6 miles	3.4 miles	94%	6 percent of spawning area above Condit Dam
Spring Chinook salmon	12.8 miles	0 miles	0%	All of spawning area above Condit Dam
Coho salmon	21.1 miles	3.4 miles	16%	Majority of spawning area above Condit Dam
Steelhead	32.9 miles	3.4 miles	10%	Majority of spawning area above Condit Dam

5.2 Freshwater Habitat

5.2.1 Lower White Salmon River Habitat Below Condit Dam

Prior to removal, operations at Condit Dam had reduced the rearing potential in the bypass reach downstream of the dam because minimum flows were 15 cfs, which was only a small percentage of the natural low flows of approximately 626 cfs (United States Geographic Survey (USGS) 2010). Power peaking associated with dam operation caused further diel flow variation, which has led to dewatering, stranding, and an increase in bioenergetic losses because of movements associated with daily flow changes.

The transport of rock and sediment, as well as nutrients, cold water and large wood down the White Salmon River stopped at Northwestern Lake. As a result, coarse material tends to dominate the reach downstream of the dam. Historically, this reach likely had more gravel,

cobble, and large wood which salmon and steelhead used as spawning habitat, than is currently present.

The removal of Condit Dam has restored normative flows in the reach. Sediment and woody material transport is also being re-established. During the years after dam removal, flows will transport fine sediment out of the previous reservoir area downstream to the CR. These sediments are likely to affect the quality of spawning habitat in the reach downstream of the dam until the river re-establishes a stable channel and the banks of the new channel also become relatively stable. The reduced habitat quality may decrease the numbers of fall Chinook salmon (and other species that stray into the lower river) that the river can support for an unknown number of years.

Steelheads use the lower reach of the White Salmon River and the area at the mouth of the White Salmon River. Other species migrating to rivers upstream of the White Salmon River use the river as a cool water refuge in the summer and also as temporary overwintering habitat (High et al. 2006; Keefer et al. 2008). By filling in rearing area and holding pools, the sediment released from behind the dam may alter this cool water refuge area for upstream migrants. The return of downstream wood transport may help to eventually deposit wood that helps to scour pools, sort sediments and create holding habitat.

5.2.2 Habitat Upstream of Condit Dam

Flow Regimes

A watershed analysis conducted by the USFS in the upper White Salmon River indicated that, based on past management activities, portions of the upper White Salmon River may be subject to increased peak flow events (USFS 1998). Tributary reaches of the White Salmon generally have more volatile flows than the mainstem White Salmon. Road building, removal of trees from riparian areas, clearing of forests and agricultural lands, loss of wetlands, and other impacts on ecosystem function may have modified the intensity of flows in some tributary reaches.

Channel Structure, Riparian Condition, and Floodplain Connectivity

Some stream reaches in the tributaries have few deep pools and little instream wood (Allen et al 2006a, 2006b; Morris 2004). Substrate in Rattlesnake Creek has a low percentage of ‘fines’ and abundance of spawning sized material (Morris 2003). No additional data representing habitat quality in the mainstem White Salmon River are available to date.

Both timber harvest and fires have impacted forested lands within the lower reaches of the watershed. Biologists consider 72 percent of riparian areas within the upper White Salmon to be late successional, as compared with 38 percent for the entire basin (USFS 2002). Small red alder tends to dominate riparian areas along Rattlesnake and Buck Creeks; conifers in the riparian area are sparse (Allen et al. 2006a, 2006b).

Roads can affect salmonid habitat by reducing natural infiltration and increasing hydro-confinement, leading to altered flow regimes, peak flows, and increased delivery of fine sediment to streams. The magnitude of effect as measured by road density is dependent upon

the number of roads, the locations of roads, the surfacing used, traffic levels, and mid-slope engineering of the road (Dubé et al. 2004).

Researchers calculated road densities (road miles/square-mile) in the upper, middle, and lower White Salmon River at 3.7 miles per square mile (2.3 kilometers per square km), 3.1 miles per square mile (1.9 kilometers per square kilometer), and 4.0 miles per square mile (2.5 km per square km), respectively. Tributary road density in the upper White Salmon ranged from 0.2 to 4.4 miles per square mile (0.1 to 2.7 km per square km) (USFWS 2002). Rattlesnake Creek has a density of 3.54 miles per square mile (2.2 km per square km) and Buck Creek a density of 5.05 miles per square mile (3.1 km per square km) (Allen and Connolly 2005). Analyses of the effects of roads on sediment inputs or stream flow have been limited to the headwaters of the mainstem (USFS 2002) and the headwaters of Rattlesnake Creek (Panakanic Watershed Analysis, http://fortress.wa.gov/dnr/forestpractices/wsasmt.cgi?wsaval=acme (accessed April 11, 2012). The Forest Service assessment identified roads that needed addressing. The upper Rattlesnake assessment found that roads were not contributing high amounts of sediment.

After the dam decommissioning efforts are completed, fine sediment will likely dominate habitat in the area previously occupied by the reservoir until such time as the fine materials deposited behind the dam are transported out of the reach, a new channel becomes established, and banks stabilize. Riparian seeding and tree planting, described in PacifiCorp's Re-vegetation and Wetlands Management Plan (PacifiCorp Energy 2010), will address the lack of riparian vegetation in the inundated area. Wood abundance may be high because the reservoir stopped downstream transport of woody debris since 1919; actual abundance will depend on the amount of wood transported into the reservoir and the decay rate of that wood.

Water Quality

Water temperature and dissolved oxygen levels in the mainstem White Salmon River are at or near optimum levels for salmonids (White and Plumb 2004). Maximum temperature within the expected anadromous range meets Washington state water quality standards with the exception of Rattlesnake Creek which approaches lethal temperatures in some locations in some years (White and Plumb 2004; White and Plumb 2005; White and Cochrane 2005, Connolly 2003; Morris 2005). Phosphorus and nitrate/nitrite in the basin (mainstem and tributaries) is very high. Phosphorus levels tend to be roughly twice the recommended EPA standard for creeks and streams and nitrate/nitrite is as much as two orders of magnitude higher that the EPA recommended standard (White and Plumb2004, 2005; White and Cochrane 2005, EPA 2000).

There are currently several segments of the mainstem White Salmon and tributaries listed as impaired waterways, 303(d) listings, by the Washington State Department of Ecology, although some of the data on which the listings are based needs updating. Ecology lists individual reaches on Gilmer Creek, Rattlesnake Creek, the mainstem White Salmon, and Trout Lake Ditch as Category 5 (water quality impaired) for fecal coliform. Temperature impairments have led to the Category 5 listing of reaches on Indian and Rattlesnake creeks http://www.ecy.wa.gov/programs/wq/303d/2008/index.html (accessed April 11, 2012).

5.3 Hatchery Production and Releases

Discussed below are effects of hatchery production and releases on White Salmon River salmon and steelhead populations.

Chinook salmon

Tule fall Chinook salmon from Spring Creek NFH contribute to natural production of fall Chinook salmon in the White Salmon River. Most of the fish spawning naturally in the White Salmon River were assumed to be hatchery-origin tule fall Chinook salmon based on CWT recoveries. Spring Creek NFH began marking all of its hatchery production and as a result, recent spawning ground surveys have shown that the majority of the tule fall Chinook salmon returning to the White Salmon River are of natural origin (Roler 2011). Spring Creek NFH tule fall Chinook salmon originally derive from White Salmon tule fall Chinook salmon and biologists and recovery planners anticipate that Spring Creek NFH tule fall Chinook salmon may be used to supplement natural production in the future. Smith and Engle (2011) collected genetic samples from juvenile salmon emigrated from the White Salmon River and determined that the naturally produced fall Chinook salmon juveniles grouped with Spring Creek NFH tules when compared to other LCR tule fall Chinook salmon populations and stray URB fall Chinook salmon.

Stray URB hatchery fall Chinook salmon may be affecting the productivity of the tule fall Chinook salmon in the White Salmon River. These URB fall Chinook salmon are strays from releases at the LWS NFH and other releases in the Bonneville Pool. Through redd superimposition, URB fall Chinook salmon can adversely affect tule fall Chinook salmon: Peak spawning time for URB fall Chinook salmon is in late October and into November after tule fall Chinook salmon spawning has been completed. Since habitat has been very limited in the White Salmon River, URB fall Chinook salmon that spawn on top of tule fall Chinook salmon redds can decrease the productivity of the White Salmon River population. The LWS NFH is taking measures to decrease the number of stray URB fall Chinook salmon. Recent escapement data for the White Salmon River has shown a decrease in the abundance of URB fall Chinook salmon spawners, but in some years, their abundance exceeds that of tule fall Chinook salmon (Roler 2011). If these measures are unsuccessful in reducing the number of stray URB fall Chinook salmon to acceptable levels, the hatchery will implement other actions.

Biologists do not know the actual stray rate of Spring Creek NFH tule fall Chinook salmon into local tributaries, but these Spring Creek hatchery fish do contribute to naturally spawning tule fall Chinook salmon in upper gorge tributaries, including the White Salmon River. The exact proportion of these hatchery fish on the spawning grounds could not be determined because only a small number of the hatchery's fish were marked. The estimated number of tule fall Chinook salmon spawners has increased in recent years peaking in 2003 with 1,575 being observed in the Wind River, 12,471 in the White Salmon River, and 10,686 in the Klickitat River (Jenkins, 2006; Roler 2009). All recent production at Spring Creek NFH fall Chinook salmon have been externally marked allowing for differentiation between natural-origin and hatchery fall Chinook salmon in the White Salmon River. All age-classes of the hatchery tule fall Chinook salmon returning to Spring Creek NFH were marked in 2010, and escapement to the White Salmon River was estimated to be composed of 1,142

natural-origin and 558 hatchery-origin tule fall Chinook salmon adults (Roler 2011). Smolt-to-adult survival rates averaged 0.136 percent for the 1991-95 brood years (Spring Creek NFH Hatchery Genetic Management Plan (HGMP) 2002). The total exploitation rate for the hatchery program was as high as 75.3 percent for the 1982-89 brood years. An estimate for brood years 1990-93 has the total exploitation rate at 67 percent, with nearly half of the impacts occurring in the CR, primarily in the Zone 6 area above Bonneville Dam (Spring Creek NFH HGMP 2002).

Hatchery-produced spring Chinook salmon are not released into the White Salmon River Basin though strays from the LWS NFH and other programs were recovered at a weir on the White Salmon River in 2009 (Engle et al. 2010).

Coho salmon

Hatchery biologists found that coho salmon from the LWS NFH had strayed into the White Salmon watershed prior to the closure of the program in 2004. Biologists consider these strays and others from releases further upstream in the CR to be the likely source of naturally spawning coho salmon in the White Salmon River.

Steelhead

Until 2010, fisheries managers released summer and winter steelhead from Skamania broodstock into the White Salmon River below Condit Dam to support tribal and recreational fisheries. Technicians marked all hatchery fish to allow for selective fisheries. These releases may limit the diversity of any naturally produced winter steelhead in the basin. However, the primary constraint on summer and winter steelhead in the White Salmon River has been the limited spawning and rearing habitat. Further, biologists do not believe Skamania stock steelhead are reproductively successful when spawning naturally; thus, adverse effects on natural populations may be limited. The hatchery terminated releases of these hatchery fish as of 2010 and biologists expect any potential impacts associated with these releases within the White Salmon will diminish after 2011. There may also be significant straying of migrating hatchery fish from other basins into the White Salmon seeking a cold water refugia (High et al. 2006, Keefer et al. 2008). These strays may originate from different DPSs including the Snake River Basin. While some may contribute to rebuilding the population, other strays may have a negative impact.

5.4 Harvest

Harvest currently does not limit the abundance or the diversity of White Salmon River steelhead, and spring Chinook salmon, coho salmon, and chum salmon, populations. NMFS considers all of these populations extirpated or functionally extirpated (Good et al. 2005; ICTRT 2007b; Ford et al. 2011). Any coho, chum, spring Chinook salmon, and most steelhead found in the White Salmon River are strays from other basins. In the White Salmon River, non-tribal coho salmon and steelhead fisheries are selective for marked hatchery fish, requiring the release of unmarked salmon and steelhead. Regulations prohibit retention of fall Chinook salmon in the White Salmon River from October 1 to December 31.

Fall Chinook salmon

Ocean fisheries off the coasts of Oregon, Washington, and British Columbia catch LCR fall-run (tule) Chinook salmon populations (NMFS 2008c). Total exploitation rates were generally higher through 1993 (averaging 69 percent), lower from 1994 to 1999 (averaging 34 percent), then increasing since 2000 (averaging 49 percent). From 2002 to 2006, regulators limited fisheries to a 49 percent exploitation rate. Total exploitation rates have been higher in some years but have averaged 49 percent from 2002 to 2006. The average exploitation rates for non-treaty fisheries in the CR for these same periods were 16 percent, 8 percent and 9 percent respectively. Tribal fisheries have a higher harvest rate on the Bonneville Pool tule populations, including the White Salmon River population (NPCC 2004; NMFS 2000).

For the last several years, NOAA Fisheries has limited Pacific Fisheries Management Council (Council) and in-river fisheries by specifying a total exploitation rate limit. From 2002 to 2006, the limit was 49 percent. The Council reduced the exploitation rate to 42 percent in 2007. NOAA Fisheries' guidance to the Council for 2008 was that Council fisheries should be managed such that the total exploitation rate on LCR Chinook salmon tule populations, from all fisheries does not exceed 41 percent. For 2009 and thereafter, NOAA Fisheries has set a total exploitation rate limit for tule Chinook salmon through their annual guidance letter to the Council. The Council's Salmon Forest Management Plan (FMP) requires NOAA Fisheries to provide such guidance. Fisheries subject to the 2008 *U.S. v. Oregon* Agreement that are part of the set of Prospective Actions must be managed subject to the overall exploitation rate limit as proposed in 2008 and have been since 1999 (NMFS 2008c). Biologists believe that tribal fisheries do not have a significant impact on the entire LCR tule fall Chinook salmon run, but do have a higher harvest rate on the Bonneville Pool tule populations, including the White Salmon River (NPCC 2004; NMFS 2000). Under the *U.S. v. Oregon* Agreement, there are a number of escapement and management objectives that limit the harvest of fall Chinook salmon in fisheries that would impact White Salmon River fall Chinook salmon, for example, a minimum escapement goal of 7,000 adults (4,000 females) to meet broodstock needs at Spring Creek NFH can restrain ocean, lower river mainstem, and above Bonneville Dam treaty fisheries (NMFS 2008c).

Tributary fisheries minimally impact tule fall Chinook salmon. The White Salmon River tributary fishery accounts for less than one percent of the total run-size of LCR fall Chinook salmon and less than 4 percent of the White Salmon River tule fall Chinook salmon (NMFS 2008c). Currently, Washington fisheries regulations allow fall Chinook salmon retention in the lower White Salmon River from July 1 to March 31 annually, but close the river to the retention of Chinook salmon ½ mile upstream from the Highway 14 bridge from October 1 to December 31 to protect spawning salmon (WDFW 2009). Catch record cards are the basis for the estimated total recreational Chinook salmon catch in the White Salmon River. These data can contain recording errors and fish misidentification, along with dip-in fish destined for upriver systems. The exploitation rate of White Salmon River tule fall Chinook salmon during WDFW-regulated fisheries in the White Salmon River is less than 5 percent of the terminal run. Biologists estimate the terminal run-size based on the annual catch rate and spawning escapement estimate data collected since 1995 (NPCC 2004). The average annual catch of wild tule fall Chinook salmon is approximately 30 fish and the average annual escapement estimate is 461, therefore, the average annual terminal run of White Salmon

River tule fall Chinook salmon is approximately 491 fish. Biologists extrapolate total run-size of the White Salmon River tule fall Chinook salmon and total fisheries impact from these data. Using the estimated annual terminal run-size and estimated annual exploitation from ocean and CR mainstem fisheries, the estimated average total run-size of White Salmon River tule fall Chinook salmon is 784 fish (NPCC 2004). The total number of fall Chinook salmon spawners (natural-origin and hatchery) has increased from low levels in the early 2000s (USFWS 2004) to an average of 2,750 for the 1998-2007 period (Roler 2009). The sport harvest has remained at roughly 30 adult fall Chinook salmon (Kraig and Smith 2008). Therefore, in recent years the proportion of the total escapement caught in the fishery has remained small.

Spring Chinook salmon

If the White Salmon River produced spring Chinook salmon, they would contribute to lower Columbia mainstem fisheries and treaty fisheries in the Bonneville Pool. Spring Chinook salmon originating from above Bonneville Dam do not contribute to ocean fisheries compared to other LCR spring Chinook salmon populations (NMFS 2008c). Fishery managers would deal with spring Chinook salmon originating from the White Salmon River as part of the upriver spring and Snake River summer Chinook salmon group. This group includes all natural and hatchery produced spring Chinook salmon originating from the CR and its tributaries above Bonneville Dam (NMFS 2008c). The abundance of this group and the status of natural-origin spring Chinook salmon from the Snake River and upper CR is the basis for establishing harvest rates for both lower river commercial and recreational fisheries and tribal treaty fisheries above Bonneville Dam. The harvest rate for this group averaged 14.5 percent from 1999 to 2008, but the actual harvest rate for prospective White Salmon spring Chinook salmon would be less because they are not exposed to the full Zone 6 (above Bonneville) treaty fishery (ODFW and WDFW 2009). Tributary sport regulations for the White Salmon River require the release of unmarked Chinook salmon from April 1 to June 30 protecting natural-origin spring Chinook salmon that may enter the White Salmon River (WDFW 2009).

Coho salmon

NMFS considers White Salmon coho salmon extinct and therefore allows no fisheries targeting coho salmon in the White Salmon River (Good et al. 2005). Stray hatchery coho salmon can be retained and all wild coho salmon must be released in fisheries downstream of the location of Condit Dam from July 1 to March 31 (WDFW 2009) LCR coho salmon are caught in both ocean and in-river fisheries. Until 1993 the exploitation rates of LCR coho salmon have been very high, contributing to their decline (NMFS 2008c). The combined ocean and in-river exploitation rates for LCR coho salmon averaged 91 percent through 1983, averaged 69 percent from 1984-1993, and decreased to an average of 16.7 percent from 1994-2007 (NMFS 2008c). The exploitation of hatchery coho salmon has remained approximately 50 percent through the use of selective fisheries.

The Pacific Fishery Management Council in accordance with the 2008 *U.S. v. Oregon* Agreement and related biological opinions regulates LCR coho salmon harvest, which is subject to a total exploitation rate limit for the combined ocean and in-river fisheries. Previously, ocean regulators used Oregon Coast natural coho salmon as a surrogate for

estimating ocean fisheries impacts to LCR coho salmon. In 2006, largely as a consequence of increased attention resulting from its listing, the methods for assessing harvest in ocean fisheries changed so that they were more specific to LCR coho salmon (NMFS 2008c).

Each year, harvest managers in the CR will set coho salmon fishing regulations, after accounting for anticipated ocean harvest, so as not to exceed the total exploitation rate limit. In 2008, the total exploitation rate limit was 8 percent based on the year specific circumstances. For 2009 and thereafter, NOAA Fisheries will set a total exploitation rate limit for LCR coho salmon through their annual guidance letter to the Council. Fisheries subject to the 2008 *U.S. v. Oregon* Agreement that are part of the set of Prospective Actions must be managed subject to the overall exploitation rate limit as proposed in 2008 and as they have been since 1999. Under the *U.S. v. Oregon* Management Agreement (NMFS 2008c) these non-treaty fisheries do not exceed the 50 percent catch sharing objective for coho salmon destined for above Bonneville Dam.

Chum salmon

In the first half of the 20th century there was a substantial commercial chum salmon fishery with a harvest rate of more than 500,000 chum salmons in some years (Myers et al. 2006). Harvest of chum salmon in the CR is limited to indirect fishery mortality. Regulators closed or drastically minimized commercial chum salmon fisheries in the 1950s due to severe population declines. Currently, there are no recreational or commercial fisheries in the CR. The number of chum salmon landed as take incidental to lower river commercial gill net fisheries has been fewer than 50 fish in each of the last five years. Harvest impacts to chum salmon from CR commercial and recreational fisheries are constantly below 5 percent and since 1998 have averaged 1.6 percent. Biologists assume ocean fishing mortality on CR chum salmon to be zero. Regulations prohibit retention of chum salmon in the White Salmon River.

Middle Columbia River steelhead

NMFS considers White Salmon River steelhead functionally extirpated (ICTRT 2007b). Any future White Salmon River produced steelhead would have similar fishery impacts as biologists have observed for steelhead destined for the other MCR Basins in Bonneville Pool. Various fisheries can catch these steelhead as they migrate through the CR and Pacific Ocean. These fisheries are discussed briefly below.

Ocean Fisheries

Ocean fisheries rarely catch steelhead; therefore, biologists do not consider these fisheries a significant source of mortality to MCR steelhead (NMFS 2000). Biologists assume ocean fishing mortality on MCR steelhead to be zero.

Columbia River Mainstem Non-Tribal Fisheries

There has been no direct freshwater non-tribal harvest on wild steelhead from the MCR steelhead DPS since 1992, when the last wild fish catch-and-release regulations on these populations became effective. Therefore, all current non-tribal harvest impacts on Mid-Columbia DPS steelhead are due to incidental by-catch in commercial or recreational fisheries that target hatchery steelhead or other species. Monitoring these impacts is

complex. Released fish experience a mortality rate, possibly delayed and difficult to measure, that is highly variable and depends on what gear is used, how the fish are caught by the gear, how the fish are handled during capture and release, and environmental conditions. Biologists estimate release mortality to be very low (below one percent of encounters (NMFS 2008c)), with an unknown range of error. Fish technicians monitor recreational fisheries by conducting creel surveys, interviewing anglers about their catch, gear, and wild steelhead releases. Biologists estimate the total recreational impact on winter and summer steelhead as they move through the mainstem to the tributaries to be less than 2.5 percent (ODFW 2008).

There are three stocks of summer steelhead used for management of treaty and non-treaty mainstem fisheries, including the LCR Skamania stock, upriver A-run stock, and upriver B-run stock. All MCR steelhead populations are designated A-run, with two populations being winter-run. In NOAA's Biological Opinion for the 2008-2017 *U.S. v. Oregon* Fisheries Agreement, the wild MCR Steelhead DPS in the non-treaty winter, spring, and summer mainstem fisheries are subject to a 2 percent harvest rate limit (NMFS 2008c). Non-treaty fall fisheries are also limited to a 2 percent harvest rate limit for A-run summer steelhead. The total annual harvest rate limit for A-run steelhead in non-treaty fisheries is 4 percent and 2 percent for the summer-run and winter-run of the MCR steelhead DPS, respectively. The expected harvest impacts from non-treaty fisheries are less than the limits proposed in the *U.S. v. Oregon* Fisheries Agreement. The yearly incidental catch of A-run steelhead in non-treaty fisheries has averaged 1.6 percent since 1999; co-managers do not expect to the incidental catch rate to change over the course of the Agreement (NMFS 2008c).

Treaty Indian Fisheries

Tribal fishers in Zone 6 of the Columbia mainstem (between Bonneville Dam and McNary Dam) continue to retain wild steelhead for commercial sale or for personal use. The *U.S. v. Oregon* Fisheries Agreement does not establish specific harvest rate limits for tribal fisheries on steelhead during the spring or summer seasons that extend through July 31. Reported steelhead catch in Zone 6 winter and spring fisheries for 2003 to 2005 ranged from 0.7 percent to 7.9 percent of the winter steelhead run over Bonneville Dam. In 2004, reported and estimated non-reported steelhead catch together amounted to 4.8 percent of the run at Bonneville, with an unknown range of error (ODFW 2008).

Harvest restrictions for B-run steelhead and upper CR bright fall Chinook salmon limit tribal fishery impacts on MCR steelhead (NMFS 2008b). The harvest rate on MCR summer-run steelhead in spring, summer, and fall Zone 6 tribal fisheries combined averaged 11.7 percent since 1985 and 6.64 percent since 1998 (NMFS 2008b, Table 8.8.5.5-1). Co-managers expect the impacts resulting from the tribal fisheries to be similar to the 1998-2006 average of 6.64 percent. The harvest rate is mostly for populations that pass more dams in Zone 6 than the White Salmon steelhead population, which passes only one Zone 6 dam. White Salmon steelheads are therefore subject to fewer non-Native American and tribal treaty fisheries and experience a harvest rate estimated to be less than 10 percent.

White Salmon River Fisheries

The White Salmon River was open year-round for marked hatchery steelhead up to the Powerhouse outfall. After dam breaching, the area open to steelhead fisheries is the lower three miles of the mainstem river, and also upriver as far as Husum. This fishery harvests

marked Skamania hatchery steelhead released in the basin as juveniles and out-of-basin steelhead that dip-in to the White Salmon River when seeking cooler water temperatures in the summer. According to catch card data available for the 2002-03 return year, fisheries harvested 3,135 marked summer steelhead and 133-marked winter steelhead (WDFW 2008). Non-tribal fisheries for Chinook salmon and coho salmon are open in the lower White Salmon River all year and require the release of unmarked Chinook salmon and coho salmon by non-tribal fishers.

5.5 Federal Columbia River Hydrosystem

Hydropower system construction and operation (flow regulation) in the CR Basin has been a major cause of changes in the CR and estuary from historical conditions.

Within the White Salmon watershed, creation of the Bonneville Dam pool on the mainstem CR affected steelhead and salmon by effectively inundating the lower 0.96 miles of the habitat. This resulted in the loss of riparian, spawning, and rearing habitat and increased predation by native and non-native fish in the lower river. The effects are greatest on White Salmon chum salmon, since the dam inundated all but 0.24 miles of their original habitat. A lack of historical data inhibits quantitative evaluation of the impacts of Bonneville pool inundation on native fish, plant, and wildlife species.

Dams altered conditions within much of the mainstem Columbia and Snake Rivers compared to historic conditions. The development of hydropower and water storage projects within the CR Basin resulted in the inundation of many mainstem spawning and shallow-water rearing areas (e.g., loss of spawning gravels and access to spawning and rearing areas); altered water quality (e.g., reduced spring turbidity levels), water quantity (e.g., seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), water temperature (e.g., including generally warmer minimum winter temperatures and cooler maximum summer temperatures), water velocity (e.g., reduced spring flows and increased cross-sectional areas of the river channel), food (e.g., alteration of food webs, including the type and availability of prey species), and safe passage (e.g., increased mortality rates of migrating juveniles) (Williams et. al 2005; Ferguson et. al 2005).

Model studies indicate that the hydrosystem and reduced river flows caused by climate change together have decreased the delivery of suspended particulate matter to the lower river and estuary by about 40 percent (as measured at Vancouver, Washington) and have reduced fine sediment transport by 50 percent or more (Bottom et al. 2005). Overbank flow events, important to habitat diversity, have become rare, in part because flow management and irrigation withdrawals prevent high flows and in part because diking and revetments have increased the "bankfull" flow level (from about 18,000 to 24,000 m3/s). The dynamics of estuarine habitat have changed in other ways relative to flow. The availability of shallow (between 10 cm and 2 m depth), low-velocity (less than 30 cm/s) habitat now appears to decrease at a steeper rate with increasing flow than during the 1880s, and the absorption capacity of the estuary appears to have declined.

The CR Estuary Module, at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm (accessed April 11, 2012), provides more information on factors that limit viability of LCR Chinook salmon and coho salmon, CR chum salmon, and MCR steelhead in the CR Estuary.

5.5.1 Hydro Project Impacts on Outmigrating Smolts

As anadromous juvenile salmonids migrate from freshwater rearing habitats to the ocean, they are vulnerable to a host of factors that affect their survival. Scientists have conducted many studies in recent years to determine both the direct effects associated with project passage (e.g., instantaneous mortality, injury, loss of equilibrium, reservoir and tailrace predation) and indirect effects (e.g., vulnerability to predation in the estuary or plume, disease, and physiological stress), which contribute to the total mortality of seaward migrating salmonids (Counihan et al. 2005).

White Salmon River salmonids must pass only Bonneville Dam on their way to and from the Pacific Ocean. The 2008 Federal Columbia River Power System (FCRPS) Biological Opinion's Reasonable and Prudent Alternative (RPA) requires a 10-year program of configuration improvements at the dam including the installation of turbines with minimum gap runners at Powerhouse 1 and increased guidance into the juvenile bypass systems at both powerhouses (NMFS 2008b). BPA will continue and further increase the pike minnow sport fishery incentive program, removing more of these predators from Bonneville pool. Upon implementation of these changes, juvenile survival from the mouth of the White Salmon to below Bonneville Dam is expected to be 95.5 percent for Chinook salmon, coho and chum salmon and 90.8 percent for steelhead (NMFS 2008b, Table 14.3 of the Incidental Take Statement).

5.5.2 Hydro Project Impacts on Migrating Adults

Passage Survival

Fish returning to the White Salmon watershed must pass Bonneville Dam and Reservoir. Prospective actions under the 2008 FCRPS Biological Opinion's RPA are expected to maintain the current high survival rates of 98.6 percent for spring-run Chinook salmon, 98.5 percent for steelhead, and 96.9 percent for fall-run Chinook salmon, coho, and chum salmon (NMFS 2008b, Table 14.1 of the Incidental Take Statement). Sea lions take about 22 percent of adult winter steelhead and 8.5 percent of adult spring Chinook salmon in the tailrace of Bonneville Dam (NMFS 2008b).

The 2008 FCRPS Biological Opinion RPA requires that the USACE install, and improve as needed, sea lion excluder gates at all main adult fish ladder entrances and must continue to support land and water based harassment efforts by NOAA Fisheries, ODFW, WDFW and the Tribes to keep sea lions away from the area immediately downstream of Bonneville Dam.

5.6 Predation, Competition and Disease

There has been an increase in abundance of predatory native and exotic fishes below Condit Dam within the reservoir created by Bonneville Dam. Primary predators of juvenile salmonids in the CR include northern pike minnow, smallmouth bass, channel catfish, walleye, terns, cormorants, and sea lions. Northern pike minnow are native cyprinids that are widely distributed throughout the CR Basin. Because these predators consume millions of salmonid smolts per year in the LCR, they are the subjects of an extensive predator control effort.

Hatchery steelhead juvenile releases into the White Salmon have probably led to competition with any natural-origin smolts produced below Condit Dam; these releases were discontinued in 2010. Hatchery adults that stray into the White Salmon River may compete for spawning and rearing habitat. Spawning of later returning URB fall Chinook salmon can reduce the productivity of naturally spawning tule fall Chinook salmon through redd superimposition.

Hatchery managers have reported Bacterial Kidney and Black Spot diseases throughout the White Salmon Basin (Allen et al. 2006a, 2006b). Now that PacifiCorp has breached Condit Dam, diseased fish moving into waters upstream of the former dam site may introduce other pathogens and/or diseases into the basin. The effects of disease on current or any potential future populations are unknown.

5.7 Ocean Conditions

The effects of ocean conditions on abundance of Pacific salmon and steelhead vary among species and populations within species. Migration patterns in the ocean may differ dramatically and expose different stocks to different conditions in different parts of the ocean. Some species have broad, offshore migration patterns that may extend as far as the Gulf of Alaska (steelhead, chum, and some Chinook salmon). Others have migration patterns along the Washington, British Columbia, Oregon, and California coasts (Chinook salmon, coho, and cutthroat salmon). Thus, ocean conditions do not have coincident effects on survival across species or populations.

Widespread changes in ocean conditions have dramatically affected ocean survival of steelhead. Cooper and Johnson (1992) showed that variation in steelhead run sizes and smolt-to-adult survival was highly correlated between runs up and down the West Coast. Smolt-to-adult survival rates generally varied 10-fold between good and bad years. Scientists know little about the early ocean life history of CR chum salmon.

5.8 Climate Change

Climate change represents a potentially significant threat to recovery of listed salmon and steelhead populations. The Independent Scientific Advisory Board (ISAB) for the NPCC, CR Basin Indian Tribes, and NMFS reviewed the potential effects of climate change on salmonids in the CR Basin (ISAB 2007). The ISAB report shows that changes in climate may adversely affect steelhead in freshwater habitats across the MCR DPS by exacerbating existing problems with water quantity (lower summer stream flows) and water quality (higher summer water temperatures). Impacts on snow pack, stream flow, and water quality in the Columbia Basin include the following (ISAB 2007):

- Warmer temperatures will result in more precipitation falling as rain rather than snow.
- Snow pack will diminish, and the timing of stream flow will be altered.
- Peak river flows will likely increase.
- Water temperatures will continue to rise.

These changes may affect steelhead more than other salmonids because of their long rearing period in freshwater.

Changing conditions could also affect salmonid health and survival in the ocean through a variety of mechanisms, including increased ocean temperatures, increased stratification of some waters, changes in the upwelling season, shifts in the distribution of salmonids, long-term variability in winds and ocean temperatures, increased acidity, and increased atmospheric and oceanic variability (NMFS 2007, 2008a; ISAB 2007).

All other threats and conditions remaining equal, future deterioration of water quality, water quantity, and/or physical habitat can be expected to cause a reduction in the number of naturally produced adult steelhead returning to these populations across the DPS. This possibility further reinforces the importance of achieving survival improvements throughout the entire steelhead life cycle. Recent research also indicates that neighboring populations with differences in habitat may show different responses to climate changes (Crozier and Zabel 2006; Crozier et al. 2008). This research reinforces the importance of maintaining habitat diversity.

5.9 Other Large-Scale Threats

Other large-scale threats that may affect salmon and steelhead populations in the White Salmon watershed in the future include the following:

- Human population growth. Pressures may increase for conversion of forestry and agricultural land uses to residential uses and residential water development, with potential impacts on habitat and water conditions.
- Increase in exotic invasive species that potentially compete with native flora and fauna. Such invasive species could provide food and/or cover to species that potentially compete with, prey on, or carry diseases that could affect native species.
- New diseases and/or pathogens. Migrating steelhead can introduce them through exposure to marine aquaculture operations or illegal stocking of out-of-watershed species, among other means.
- Natural catastrophic events.(e.g., earthquakes, volcanic eruptions, and large-scale forest fires).

Table 5-2 lists the primary factors limiting the production of fall Chinook salmon, the only extant population in the White Salmon River drainage. Table 5-3 lists the combined factors limiting the production of the extirpated or functionally extirpated spring Chinook salmon, coho, and chum salmon, and steelhead populations within the White Salmon watershed. Also listed are the potential impacts on population VSP parameters, sites where these impacts may be observed, the underlying anthropogenic threats, life stage affected, significance, and actions that would address the limiting factors.

Table 5-2. Primary limiting factors for lower Columbia River fall Chinook salmon in the White Salmon River drainage

Limiting Factor	VSP Parameter Impacted	Sites Affected	Threats	Life Stages Affected	Significance (Scope/Severity)	Actions
Lack of spawning gravel and spawning area	Abundance, productivity	Lower 3.3 RM of mainstem White Salmon River	High fine sediment loads delivered from the former Northwestern Lake	Spawning and incubation	Fine sediments accumulated in the bottom of the former Northwestern Lake will be transported into the lower 3.3 miles of the river for potentially many years. These fine sediments will tend to settle out in lower gradient areas and will also tend to build up during lower flow periods. The net effect on habitat remains unknown.	Restoration of habitat in the reaches formerly occupied by Northwestern Lake and downstream of the former dam site. Natural processes will eventually come to an equilibrium.
Harvest	Abundance, productivity	All, but especially ocean and Columbia River fisheries	Commercial, recreational, and tribal fisheries	Upstream migration, ocean survival	Significant harvest of fall Chinook salmon is allowed annually. While the specified allowed harvest is expected to result in gradual population growth, the allowable rate of harvest may slow recovery	Modify fisheries
Genetic changes and/or competition with hatchery fish	Genetic diversity, abundance and productivity	All spawning areas	Strays from other areas	Spawning and rearing	Unknown	Monitor

Table 5-3. Additional factors potentially limiting anadromous fish (lower Columbia River spring Chinook salmon and coho salmon, Columbia River chum salmon, and middle Columbia River steelhead in the White Salmon River drainage). The primary limiting factors are highlighted in light yellow; factors that may become limiting in the future are highlighted in light gray.

Limiting Factor	VSP Impacted Parameter	Sites Affected	Threats	Life Stages Affected	Significance (Scope/Severity)	Actions
Lack of an extant viable population	Abundance and Productivity	All	Populations of steelhead, spring Chinook salmon, coho salmon, and chum salmon are considered extirpated or functionally extirpated	All stages	Re-colonization by the extirpated species will be limited to natural repopulation of the basin through straying	The preferred approach for reintroduction of species into the basin is to allow natural straying into the river. Hatchery alternatives may be implemented if population recovery is determined to be too slow.
Harvest	All	All	Now that the dam has been removed, an abundance of unoccupied habitat has become available. Harvest will directly affect the rate of species re-colonization and population growth.	All	Will delay the rate of recovery in direct proportion to the numbers of fish potentially spawning in the basin that are caught	Manage fisheries to increase the potential for escapement into the White Salmon River.
High sediment loads in the reaches formerly occupied by Northwestern Lake and the reaches downstream of the former lake and a lack of suitable spawning habitat downstream of Buck Creek	Abundance and Productivity, spatial structure and diversity	All	The high sediment loads mobilized out of the area of the former lake may eradicate suitable spawning habitat downstream of Buck Creek for many years. The absence of quality spawning habitat in the lower reaches may deter stray fish from moving into the upper basin where	All	May delay re-colonization of the basin	Implementation of PacifiCorp's Dam Decommissioning Plans. Additional analysis of both habitat and re-colonization rates will be required to determine if additional actions are needed.

Limiting Factor	VSP Impacted Parameter	Sites Affected	Threats	Life Stages Affected	Significance (Scope/Severity)	Actions
			good spawning habitat is available.			
Factors that may become limiting as the populations grow						
Stream flow	Primarily abundance and productivity	Buck Creek	Water diversions.	Fry colonization, inactive age-0 and 1, juvenile rearing, migration	Diversion withdraws 70 percent of flow from Buck Cr., while unused portion returns to White Salmon via gully	Address Buck Creek water diversion
Large Woody Debris abundance	Primarily abundance and productivity	Mainstem White Salmon upstream of Buck Creek and lower White Salmon River mainstem.	Removal of wood for recreation; land use practices that reduce riparian forests	Fry colonization, juvenile rearing, overwintering, pre-spawners, spawners	Lack of LWD reduces pool habitat, sediment sorting and habitat complexity	Place LWD as appropriate and feasible. Address wood removal by boaters. Add structure to form pools
Stream temperatures	Abundance, productivity, spatial structure and diversity	Indian and Rattlesnake Creeks, lower Buck Creek, and possibly the reaches formerly occupied by Northwestern Lake	Land use practices that reduce riparian function; lack of riparian vegetation within the footprint of the former Northwestern Lake	Juvenile rearing, active age-0, spawning, migration	Currently the problem exists primarily in Rattlesnake and Indian Creeks, but may become a problem in the reaches previously occupied by the reservoir.	Increase shading along temperature limited reaches.
Harassment, predation and competition	Primarily abundance, productivity	Bonneville Pool	Inundation by Bonneville Pool	Adult migrants, pre-spawners, holding	Increase in exotic species and recreational activity in lower river	Improve programs that target exotic piscivorous fish in the mainstem Columbia

6 Recovery Strategy and Actions

The preceding chapters summarize recovery goals, biological and threats criteria, current status assessment, and the major limiting factors and threats identified for the White Salmon River salmon populations. How will we reach recovery? The White Salmon recovery strategy contains two key parts: 1) a plan for reintroducing naturally produced salmon and steelhead into historical habitat after the removal of Condit Dam, 2) improving and increasing freshwater habitat for salmon and steelhead production in key reaches of the watershed. The Plan also recommends ensuring that harvest or hatchery actions do not impede efforts to improve salmon and steelhead viability.

Blocked passage at Condit Dam was the primary limiting factor for both salmon and steelhead until the dam was breached in October 2011, and completely removed in October 2012. The methods considered to reintroduce salmonids to their historical habitat, included natural re-colonization, artificial propagation, or some combination of the two. Section 6.1 and Appendix I describe reintroduction plans.

Sections 6.2 through 6.5 also propose additional actions regarding freshwater habitat, hatcheries, harvest, and hydrosystem operations.

6.1 Salmon and Steelhead Reintroduction Plans

The White Salmon Working Group, made up of Federal, state, and tribal fisheries managers, as well as representatives of PacifiCorp (Condit Dam operators), developed several options to consider for the reintroduction of salmon and steelhead into the White Salmon River. The group fleshed out each option with a description of the biological basis for the approach, operational and maintenance needs, and monitoring and evaluation needs. For more details about the options and considerations, see Appendix I.

Some members of the White Salmon Working Group proposed that after Condit Dam removal or passage restoration, the reintroduced/re-colonized populations in the White Salmon River be experimental populations pursuant to section 10(j) of the ESA. However, these fish would not meet the ESA's definition for an experimental population, which is defined, in part, as one that is "wholly separate geographically from non-experimental populations of the same species."

After the removal of Condit Dam, populations of Chinook salmon, coho salmon, and steelhead cannot remain "wholly separate geographically" from other populations within the listed ESU/DPS. Keeping the populations "wholly separate" from the other populations within the listed species is also not consistent with the recovery strategy where the goal is for listed species from neighboring populations to re-colonize the habitat above Condit Dam after its removal. Furthermore, as Sections 2.4.4 and 6.1.5 (MCR steelhead) describe, the steelhead population in the White Salmon River still evidence some of its ability for anadromy and is not wholly extirpated.

6.1.1 Fall Chinook salmon

The White Salmon Working Group agreed on a salvage plan for tule fall Chinook salmon to maintain natural production assuming Condit Dam removal. Beginning in 2008, biologists tested a salvage plan to see if technicians could capture enough adult tule fall Chinook salmon below Condit Dam and safely transport them to spawning habitat above the dam. Biologists monitored the transported tule fall Chinook salmon to determine post-release survival, movement, and spawning habitat preferences (Engle and Skalicky 2009). In 2009, technicians installed a weir at the White Salmon Ponds site and tested increasing adult salmon collection and estimating escapement above the White Salmon Ponds site (Engle et al. 2010).

The White Salmon Working Group evaluated the following options for tule fall Chinook salmon (see Appendix I for detailed descriptions).

1. Salvage adipose present CWT-negative tule fall Chinook salmon from the White Salmon River in the fall of 2010 to start tule fall Chinook salmon restoration.
2. Spring Creek NFH would spawn adults and rear eggs. The hatchery would acclimate and release the resulting juveniles at White Salmon Ponds.
3. Salvage adipose present CWT-negative tule fall Chinook salmon returning to Spring Creek NFH to start tule fall Chinook salmon restoration.
4. Outplant adults, adipose present, in 2011 above Condit Dam prior to removal.
5. No salvage effort in the White Salmon River or at Spring Creek NFH. Salvage adipose present CWT-negative tule fall Chinook salmon returning to the White Salmon River and outplant above Condit Dam prior to removal.

The White Salmon Working Group selected the outplant option (Option 4) for tule fall Chinook salmon because they believed that the habitat currently available above Condit Dam that can support natural spawning tule fall Chinook salmon and because this option would minimize the potential impacts of hatchery rearing. Biologists tested a number of collection alternatives 2008 to ensure that technicians could collect unmarked tule fall Chinook salmon in adequate numbers and safely transport them above Condit Dam (Engle and Skalicky 2009). In 2008, the goal was to transport up to 500 adults made up of marked hatchery fall Chinook salmon collected in the lower White Salmon River and fall Chinook salmon from Spring Creek NFH. Hatchery fall Chinook salmon were used for this test because Condit Dam did not have a system to safely pass juvenile salmon during their outmigration. In 2008, technicians collected 90 adults in the White Salmon River and transported 333 adults from Spring Creek NFH to habitat above Condit Dam (Engle and Skalicky 2009).

Monitoring of the transported adults determined the movement of adults after release, where spawning occurred, and determined that spawning was successful. The White Salmon Working Group is finalizing an operating plan for collection and transportation of adult tule fall Chinook salmon in 2010 (see Engle and Skalicky 2009). In 2009, technicians installed a weir and tested it adjacent to the White Salmon Ponds, using the historic weir location to collect more tule fall Chinook salmon adults (Engle et al. 2010). In 2011, prior to Condit Dam breaching, a total of 679 tule fall Chinook salmon were collected from the lower White

Salmon River and transported and released between Husum Falls and Northwestern Lake, of these 552 were determined to be natural-origin. Furthermore, spawning ground surveys determined that spawning was successful below Husum Falls (R. Engle, USFWS, November 2012, personal communication).

6.1.2 Spring Chinook salmon

The White Salmon Working Group reviewed the following options for reintroducing spring Chinook salmon into White Salmon River (see Appendix I for detailed descriptions).

1. Natural colonization, i.e., no active reintroduction efforts from outside sources.
2. Wild Klickitat spring Chinook salmon as brood source for juvenile release into the White Salmon River. Eggs collected and reared at Klickitat Hatchery, juveniles acclimated and released at White Salmon Ponds.
3. Klickitat Hatchery spring Chinook salmon as brood source for juvenile release into upper White Salmon River, starting in the spring of 2010 (from Klickitat Hatchery thinning release or other surplus juveniles).
4. Klickitat Hatchery integrated stock spring Chinook salmon as brood source for juvenile release into White Salmon River, in future years (broodstock source would be hatchery-reared offspring of wild fish).
5. Transport surplus Klickitat Hatchery adults to White Salmon starting in the fall of the year of removal.
6. Trap and transport Klickitat wild adults to White Salmon starting in the fall of the year of removal.
7. Monitor natural escapement and production for 4-5 years then evaluate need and suitability of Option 4.

The White Salmon Working Group decided on Option 7 for spring Chinook salmon. Under this option Working Group members propose to monitor escapement of spring Chinook salmon into the upper White Salmon River, including the proportion of Carson stock hatchery spring Chinook salmon on the spawning grounds. The Working Group also will monitor spring Chinook salmon smolt production in the upper White Salmon River. The 4-5 year monitoring period will determine if natural production is occurring and the source of that production. The monitoring period will also allow time for the development of the Klickitat Hatchery integrated spring Chinook salmon program and determine whether production capacity at this facility is available. The White Salmon Working Group considered the Klickitat Hatchery spring Chinook salmon program the best source of broodstock for reintroduction, even though it is not part of the LCR Chinook salmon ESU because it is within the transition zone between LCR and interior CR populations (Ford et al. 2011). The two nearest populations of spring Chinook salmon within the LCR ESU are in the Lewis River in Washington and the Sandy River in Oregon. Each of these basins have spring Chinook salmon hatchery programs but reintroduction efforts in the Lewis River Basin require current local production, while broodstock collection and funding shortfalls constrain production in the Sandy River. The result is the unavailability of a suitable source

of spring Chinook salmon stock to support the reintroduction efforts in the White Salmon River. NMFS is currently reviewing whether a population re-established in historic habitat using a non-ESU spring Chinook salmon stock can be part of the listed ESU for recovery and delisting purposes. The Hood River spring Chinook salmon recovery efforts are using a non-ESU spring Chinook salmon stock for reintroduction.

6.1.3 Coho salmon

The White Salmon Working Group reviewed the following options for reintroducing coho salmon into White Salmon River (see Appendix I for detailed descriptions).

1. Natural re-colonization, i.e., no reintroduction efforts from outside sources.
2. Juveniles from Washougal and/or Bonneville/Cascade hatcheries released into White Salmon River.
3. Collection of wild adult broodstock in Klickitat River with spawning and rearing at hatchery facility and juvenile release in White Salmon River.
4. Collection of wild adult broodstock in White Salmon River with spawning and rearing at hatchery facility and juvenile release in White Salmon River.
5. Monitor natural escapement and production for 4-5 years then evaluate need and suitability of Options 2, 3 or 4.

The White Salmon Working Group decided on Option 5 for coho salmon. As described for spring Chinook salmon, the Working Group members propose to monitor escapement, hatchery- and natural-origin coho salmon on the spawning grounds, and juvenile production in the White Salmon River Basin. Sources of stray hatchery coho salmon include releases from Bonneville Hatchery and releases into the Klickitat and Umatilla River basins. All of these releases derive from hatchery programs that are part of the LCR coho salmon ESU. A recovery team will use the results of the monitoring efforts to determine future reintroduction activities.

6.1.4 Chum salmon

The White Salmon Working Group reviewed the following options for reintroducing chum salmon into White Salmon River (see Appendix I for detailed descriptions).

1. Natural re-colonization, i.e., no reintroduction efforts from outside sources.
2. Active adult outplanting in years after Condit Dam removal.
3. Active stocking of juvenile chum salmon or outplanting of eggs in egg baskets and hatch boxes via WDFW's Washougal Hatchery or Willard NFH.
4. Initiate temporary hatchery program for chum salmon using existing USFWS hatcheries for subsequent outplanting of chum salmon captured at Bonneville Dam.

The White Salmon Working Group decided on Option 1 for chum salmon. The group chose this option because of the uncertainty regarding the status of chum salmon above Bonneville

Dam. This option calls for expanded spawning ground surveys in the Bonneville Pool using the mainstem chum salmon spawning habitat criteria developed for the population below Bonneville Dam. Those conducting surveys should focus in the lower reaches of suitable tributaries and include habitat suitability assessments for the reservoir and the tributaries.

6.1.5 Steelhead

The White Salmon Working Group reviewed the following options for reintroducing steelhead into White Salmon River (see Appendix I for detailed descriptions).

1. Natural re-colonization, i.e., no reintroduction efforts from outside sources.
2. Wild donor from local watershed as brood source for juvenile release into the White Salmon River. Eggs collected and reared at suitable hatchery and juveniles acclimated and released at White Salmon Ponds.
3. White Salmon resident *O. mykiss* as brood source, with locally suitable anadromous wild donor stock spawned for juvenile release into upper White Salmon River.
4. White Salmon steelhead captive brood program using captured outmigrating juveniles.
5. White Salmon steelhead kelt reconditioning. Recondition local spawners to enhance survival.

Based on the potential to re-establish natural production of steelhead in the basin, the White Salmon Working Group decided that Option 1, natural re-colonization, was the best approach. Indications that the (resident) population of *O. mykiss* in the White Salmon River above Condit Dam still produces smolts, even though the construction of Condit Dam and the end of passage in 1913 eliminated anadromy, was the basis of the group's decision. Recent monitoring in the White Salmon River above Condit Dam has identified *O. mykiss* juveniles displaying smolt behavior and morphology. Biologists detected juveniles PIT-tagged in Rattlesnake Creek passing Bonneville Dam, with one recovered at the tern colony on East Sand Island (B. Allen, personal communication, 2007). In addition, biologists detected a juvenile *O. mykiss* PIT-tagged above Condit Dam in September 2004 at 98 mm ascending Bonneville Dam in July 2006. Genetic analysis of juvenile *O. mykiss* collected in the upper watershed above Husum Falls found differences from hatchery trout released in the basin; additional samples are needed, however, to confirm this finding (Allen et al. 2006).

Additional research by Carmichael (Ruzycki 2003) in the Grande Ronde and by Thrower et al. (2004) in Alaska has identified a potential strategy for steelhead in the White Salmon. Research conducted by Thrower et al. (2004) indicated that:

> after 70 years of freshwater residency, a formerly anadromous, wild, freely breeding population of *O. mykiss* has retained large amounts of genetic variability associated with growth, precocious maturation and smolting despite complete selection against the phenotypic expression of at least one of the fitness related characters (smolting migration) critical for the re-establishment of an anadromous population…. Genetic potential for smolting can lie dormant or be maintained through a dynamic

> interaction between smolting and early maturation for decades despite complete selection against the phenotype. The results have significant implications for the preservation of threatened anadromous stocks in fresh water and the inclusion of resident fish of formerly anadromous populations, currently trapped behind longstanding barriers to migration, as one component of the same population.

This information supports the theory that even though the population is functionally extirpated, there is some the potential for re-establishing anadromous steelhead in the White Salmon River Basin. Using resident *O. mykiss* above Condit Dam will provide a genetic link to historical anadromous *O. mykiss*.

6.1.6 Monitoring and Evaluation

The key to the success of all of these options is to implement all of the proposed monitoring and evaluation activities, including development and implementation of an approach to monitor adult escapement, adult movement, presence/absence of stray hatchery-origin salmon and steelhead, and population productivity. In the future, if the need arises, and after careful evaluation and consensus among the co-managers, biologists could use a weir to exclude hatchery-origin adults, thus creating a refuge for naturally produced salmon and steelhead. Another reason that the White Salmon Working Group supported these options was that the removal of Condit Dam provides a rare opportunity to study the natural re-colonization of newly available habitat without using hatchery intervention. The proposed White Salmon Recovery Board and NMFS will evaluate the proposed options and make an assessment after 5 years to determine the next steps for reintroduction of salmon and steelhead in the White Salmon River.

Much remains unknown about the current status of the historical salmon and steelhead populations in the White Salmon and the capability of the habitat to support increased production. This Plan proposes the following actions to establish a baseline of current population status and habitat conditions and to help ensure that efforts to reintroduce salmon and steelhead in the White Salmon are efficient and successful. The YN, USGS, WDFW, USFWS, and UCD identified these actions. Chapter 8 offers further discussion of basin-wide monitoring and evaluation activities.

Biologists need to gather data and analyze information needs upstream and downstream of Condit Dam now that PacifiCorp has removed the dam. This information will inform project selection and implementation and improve the rate and success of reintroduction.

Below is a description of a multi-agency cooperative process for planning reintroduction. Table 6-1 summarizes the biological objectives, actions, and existing strategies for data gathering and analysis; it also outlines some needed habitat restoration. The YN, USGS, WDFW, USFWS, and UCD agreed to these general biological objectives and provided the detailed actions for which they would accept responsibility. In 2012, the White Salmon Working Group will work to refine the monitoring and evaluation plan to reflect the removal of Condit Dam in 2011.

Various management entities have implemented some of these monitoring and evaluation activities starting in 2006 and continued these activities through the removal of Condit Dam

(e.g., Allen et al. 2006; Smith et al. 2007). Recovery planners are seeking funding to continue the monitoring post-dam removal.

Table 6-1. Biological objectives, management strategies, and actions to enhance/reintroduce anadromous salmonid populations and acquire baseline habitat information in the White Salmon River Basin

Biological Objective	Full Description	Actions and Existing Strategies
Implement reintroduction plan	Salmon and steelhead will be allowed to naturally re-colonize habitat above the former Condit Dam. Intensive monitoring activities will be implemented, including implementation of a program designed to monitor adult and juvenile abundance	Continue monitoring activities already occurring in the basin and expand to include population monitoring in the White Salmon River and Rattlesnake Creek
Complete gathering of information on existing salmonid stocks	Determine the status, life histories, and genetic composition of fish populations in the White Salmon River and its tributaries that are now accessible to anadromous salmonids.	Finalize adult and juvenile monitoring program for existing stocks in the White Salmon River. Assess interaction of bright and tule Chinook salmon populations and rainbow and steelhead
Hatchery status monitoring	Monitor the proportion and origin of hatchery salmon and steelhead on the spawning grounds	Continue to count adipose marked and unmarked carcasses and tagged adults
Maintain genetic diversity of listed salmonids	Continue to monitor current salmonid species composition and viability to determine effects of reintroduction actions	To maintain the genetic diversity of salmonid species in the White Salmon River complete analysis of information that describes the stocks and genetic diversity that currently exists
Population status monitoring	Monitor salmon and steelhead spawning escapement to estimate viable salmonid population parameters	Estimate population abundance using statistically robust methodologies
Assess effect of anadromous fish on resident fish	Assess the resident fish population prior to the reintroduction of anadromous salmonids	Assess resident trout contribution to smolts. Establish comprehensive monitoring program (of trout population). Assess change in resident population after steelhead re-colonization/reintroduction begins

6.2 Freshwater Habitat Strategies and Actions

This plan proposes a number of freshwater habitat strategies and actions to rebuild the salmon and steelhead populations in the White Salmon River drainage to the desired levels of viability. The Plan recognizes that anadromous salmonids did not occupy the habitat upstream of the former Condit Dam; therefore habitat upstream of the dam was not limiting the population. However, now that the river upstream of the dam is becoming accessible, and anadromous salmonids are beginning to use this habitat, factors such as head cutting at the head of the old reservoir and the practice of removing large woody debris could limit the carrying capacity of the existing habitat. The factors limiting the populations during the process of rebuilding will be habitat affected by dam removal, or an out-of-basin factor such as harvest, predation, or ocean conditions which affects the rate of population growth.

Habitat downstream of the dam currently affects salmon production. With the removal of Condit Dam, the habitat downstream of the dam has changed dramatically and the habitat within the footprint of the existing reservoir may be of very low quality. Restoration of the habitat in those areas will be a priority.

Restoration of upstream habitats is also included in this Plan. Salmonids will eventually fully occupy the upstream habitats. Immediate initiation of restoration activities in the upstream habitats will ensure that quality habitat is available as the populations grow.

Maintenance and protection of existing high quality habitats to ensure no net loss in quantity or quality of existing available habitat can also be an important element in providing for the development of salmonid populations in the basin. Land use planning, implementation of BMPs, acquisitions, easements, cooperative agreements, protective land designations, and voluntary commitments are potential tools for protecting and maintaining high quality habitat.

The Plan defines four freshwater habitat strategies: 1) gain information needed to identify and prioritize habitat actions that will provide the greatest opportunity to contribute to recovery, 2) restore mainstem habitat downstream of Buck Creek, 3) protect and conserve existing natural ecological processes, 4) improve habitat in upriver reaches. The fourth strategy addresses habitat improvement in upriver reaches that anadromous populations have recently begun to occupy. Because the fourth strategy does not address a known limiting factor, it is therefore a broad-sense strategy. The White Salmon Working Group defined the strategies and actions through review and analysis of currently available information. Many reaches in the White Salmon watershed have quality habitat and functional ecological processes that are currently capable of supporting anadromous fish populations or have moderate habitat quality and quantity and the potential to become high quality habitat (White and Cochrane 2005; Morris 2003, 2004, 2005; Allen et al. 2006a, 2006b; White and Plumb 2004, 2005). The strategies and actions address risks that the TRT identified in viability assessments for the populations.

This Plan designed the strategies and actions together to protect and improve freshwater habitat in the drainage and, thus, improve the potential productivity of White Salmon salmonid populations. The Plan's actions to restore passage and habitat also expect to benefit other anadromous and resident species, including cutthroat trout and Pacific lamprey

(*Lampetra tridentata*), a candidate for ESA listing and an important food source for members of the YN. Table 6-2 summarizes the strategies and actions related to improvement of freshwater habitat. Table 6-3 summarizes proposed habitat related actions associated with the fourth strategy: improve habitat that anadromous populations may eventually occupy.

Table 6-2. Primary biological objectives, management strategies, and actions to improve habitat in the White Salmon River watershed

Biological Objective	Species	Full Description	VSP Parameter Addressed	Actions and Existing Strategies
Gain information needed to identify and prioritize habitat actions that will provide the greatest opportunity to contribute to recovery	All species	Complete habitat surveys to help prioritize restoration needs and measure select habitat attributes above and below Condit Dam to document changes associated with removal of the dam as well as documenting time to recovery	All	An assessment of existing conditions is needed to prioritize recovery efforts
Restore mainstem habitat downstream of Buck Creek	All species	The effects of dam removal can only be estimated. With the dam removed, surveys will need to be conducted to a) document the habitat conditions immediately after removal, b) document changes in habitat over time, and c) identify and prioritize habitat restoration projects	All	Restore habitat through the implementation of PacifiCorp's Decommission Management Plans Complete surveys following dam removal. Identify and implement priority actions for habitat restoration such as bank stabilization of restoration of native vegetation.
Protect and conserve existing natural ecological processes.	All species	Protection and conservation of existing habitat will ensure that quality habitat is available as populations grow and will help to avoid additional impacts to habitats currently in use	All	• Land use planning to minimize anthropogenic effects • Land acquisition and conservation • Adoption and management of conservation agreements • Application of BM P BMPs • Public outreach to educate river uses and others

Biological Objective	Species	Full Description	VSP Parameter Addressed	Actions and Existing Strategies
Restore riparian vegetation along stream sections that exceed state standards for temperature	All species	Some stream segments within the expected range of anadromous salmonid distribution are known to be excessively warm. Since it takes time to grow trees that will eventually provide shade, planting of trees and implementing other programs to restore and protect riparian conditions is desirable in the near term	All	• Identify stream segments that are excessively warm within the expected anadromous salmonid distribution • Where riparian trees are sparse, implement programs to increase the density of the riparian vegetation • Implement programs to protect existing riparian vegetation

Table 6-3. Biological objectives, management strategies, and actions to improve habitat in the upper White Salmon River watershed

Biological Objective	Species	Full Description	VSP Parameters Addressed	Actions and Strategies
Additional Freshwater Habitat Strategies and Actions Addressing Likely Future Limiting Habitat Factors and Habitat Quality				
Improve habitat in upriver reaches	All populations	Protect and conserve natural ecological processes that support the viability of populations and their primary life history strategies throughout their life cycle Priority locations: Rattlesnake Creek, Indian Creek, Buck Creek, White Salmon River (Buck Creek to Husum Falls),	All Parameters	• Protect highest quality habitats through acquisition and conservation • Adopt and manage conservation agreements • Consistently apply BMP BMPs and existing laws to protect and conserve natural ecological processes • Provide public outreach to educate river uses and others

Biological Objective	Species	Full Description	VSP Parameters Addressed	Actions and Strategies
		Spring Creek		
	All populations	Gain information needed to identify and prioritize habitat actions that will provide the greatest opportunity to contribute to recovery Priority locations: Watershed areas above Buck Creek, with emphasis on the mainstem	All	• Conduct habitat surveys to help prioritize restoration needs • Implement projects to improve habitat
	All populations	Restore passage and connectivity to habitats blocked or impaired by artificial barriers Priority locations: Buck Creek	Abundance Productivity Spatial Structure	• Remove or replace barriers blocking or impairing passage including dams, dikes, road culverts, and irrigation structures • Provide screening at 100 percent of irrigation diversions • Replace screens that do not meet criteria
	All populations	Reduce nutrient loads; Nutrient levels in the White Salmon Basin are high (White and Plumb 2005; White and Cochrane 2005). The nutrient enrichment may decrease juvenile or adult fish survival. A rehabilitation strategy is recommended. Monitoring will help determine if actions taken have improved the situation	Abundance Productivity Spatial Structure	• Reduce runoff from septic tanks • Reduce nutrient runoff from dairies and agricultural lands
	All populations	Improve floodplain connectivity and function and channel migration processes	Abundance Productivity	• Reconnect side channels and off-channel habitats to stream channels • Restore wet meadows • Reconnect floodplain to channel

Biological Objective	Species	Full Description	VSP Parameters Addressed	Actions and Strategies
		Priority locations: Rattlesnake Creek, Indian Creek, Buck Creek, White Salmon River (Buck Creek to Husum Falls), Spring Creek	Spatial Structure	• Relocate or improve floodplain infrastructure and roads • Conduct public awareness and education about restoration efforts
	All populations	Improve channel structure and complexity Priority locations: Rattlesnake Creek, Indian Creek, Buck Creek, White Salmon River (Buck Creek to Husum Falls), Spring Creek	Abundance Productivity	• Place stable wood and other large organic debris in streambeds • Stabilize streambanks • Restore natural channel form
	All populations	Improve riparian condition and LWD recruitment Priority locations: Rattlesnake Creek, Indian Creek, Buck Creek, White Salmon River (Buck Creek to Husum Falls), Spring Creek	Abundance Productivity	• Restore natural riparian vegetative communities • Develop grazing strategies that promote riparian recovery • Eradicate invasive plants species from riparian areas
	Steelhead Spring Chinook salmon Coho salmon	Reduce anthropogenic effects on hydrograph to provide appropriate flows during critical periods Priority locations: Rattlesnake Creek, Indian Creek, Buck Creek	Abundance Productivity	• Implement agricultural water conservation measures • Improve irrigation conveyance and efficiency • Restore natural functions and processes through actions identified in strategies above • Employ BMPs to forest, agriculture, and grazing practices and to road management • Protect and/or rehabilitate springs • Increase pool habitat • Restore wetlands and other water holding capacity on plateau

Biological Objective	Species	Full Description	VSP Parameters Addressed	Actions and Strategies
	All populations	Reduce summer water temperatures Priority locations: Rattlesnake Creek, Indian Creek, Buck Creek	Abundance Productivity	• Improve riparian vegetation • Reduce sediment inputs to streams

6.2.1 High Priority Reaches for Habitat Protection/Restoration and Proposed Actions

The White Salmon Subbasin Plan (NPCC 2004) identifies the following areas as high priority reaches for protection and restoration (based on anticipated potential distribution):

- Steelhead habitats are likely concentrated in the White Salmon River mainstem upstream to Husum Falls and in Rattlesnake Creek. The reach between Husum Falls and Big Brother Falls, RM 16.2, may also contain potential habitat. Rattlesnake Creek has an abundance of rainbow trout as well as numerous restoration opportunities.
- Spring Chinook salmon will likely concentrate in habitats in the mainstem reaches downstream of BZ Falls, RM 12.4. This habitat area would include the reaches downstream of the former Condit Dam, the footprint of the reservoir, and reaches between Buck Creek and BZ Falls. With the dam's removal, significant, high priority restoration opportunities exist.
- Coho salmon would likely utilize both the lower river and the upper river habitats, including the tributaries (Rattlesnake, Spring, and Buck creeks).
- Fall Chinook salmon are likely to concentrate in areas downstream of Condit Dam, and upstream as far as Husum Falls after passage resumes.
- Chum salmon are likely to concentrate near the mouth of the White Salmon River.

The following areas rank as the highest priorities for habitat restoration. Reasons for their ranking and actions proposed to address limiting factors and threats are summarized below based on information provided in White and Cochrane (2005), Morris (2003, 2004, 2005), Allen et al. (2006a, 2006b), White and Plumb (2004, 2005), EDT modeling results (Allen and Connolly 2005), the White Salmon Subbasin Plan (NPCC 2004), and Klickitat Lead Entity Region Salmon Recovery Strategy (Klickitat Lead Entity 2005).

White Salmon River Mainstem - Site of Condit Dam, RM 3.3

Achieving multiple DPS/ESU population recovery goals depends largely on the success of efforts to restore passage to upriver spawning and rearing habitats and improve flow and habitat conditions in the lower river.

Actions:

- The complete removal of Condit Dam to provide unimpeded upstream passage by adult and juvenile salmonids.
- Improve flow and habitat conditions in the lower White Salmon River.

White Salmon River Mainstem - Mouth to Condit Dam

After breaching, sediment loads below the dam site have increased, directly impacting fall Chinook salmon present in the reach at the time of dam removal. Sediment loads will impact potential spawning and rearing habitat for Chinook salmon, chum and coho salmon in the lower White Salmon River, and will impact the migration corridors for all anadromous species. An assessment of conditions after dam removal will determine the best approach to restoration.

Actions:

- Restore habitat through the implementation of PacifiCorp's Decommissioning Management Plan.
- Assess limiting habitat features due to dam removal and restore habitat as needed to provide for spawning, rearing, and adult holding and migration.
- Place LWD and gravel as appropriate.

White Salmon River Mainstem - Condit Dam to Buck Creek

This reach currently contains the section under the former Northwestern Reservoir. It should provide important habitat for salmon and steelhead spawning, rearing, migration, and adult holding after the effects of the Condit Dam removal are addressed. Large quantities of sediment have accumulated in the reservoir since the original owners built the dam in 1913. With the dam's removal, it may require years for the river to establish a stable channel. The banks of the river will tend to slough and erode until they reach a stable angle of repose and attain sufficient vegetation to reduce erosion and stabilize slopes. The time needed to re-establish a stable channel with clean gravels is unknown. Recovery planners and fish managers could take actions to hasten restoration. Biologists cannot identify the precise set of actions with any confidence until they evaluate the habitat conditions post-dam removal.

Actions:

- Restore habitat through the implementation of PacifiCorp's Decommissioning Management Plan.
    - Assess habitat-limiting features and identify restoration needs.
    - Implement projects to restore habitats, including planting of native vegetation.

White Salmon River Mainstem - Buck Creek to Husum Falls

This reach extends from the headwaters of the former Northwestern Lake to Husum Falls. The reach has high potential for salmon and steelhead spawning, rearing, and adult holding. USFWS also listed the mainstem White Salmon River up to Husum Falls as proposed critical habitat for bull trout; that same habitat is important for coastal cutthroat trout. Habitat in the reach generally remains in good condition. Therefore, recovery planners proposed no actions, though as use by anadromous fish increases, an assessment of the habitat in this section should be completed.

White Salmon River Husum to BZ Falls

There is little data available regarding habitat conditions between Husum and BZ Falls. This reach would likely support coho salmon and steelhead and possible spring Chinook salmon. Biologists generally think the reach is in good condition, making restoration in this reach a lower priority. The primary action for this section would be to assess habitat features and restore habitat as needed to provide for spawning, rearing, and adult holding and migration.

Rattlesnake Creek

Rattlesnake Creek and its tributaries provide significant spawning and rearing habitat for rainbow trout and likely highly productive habitat for coho salmon and steelhead once fish can pass to these upstream areas. The reach has low quality pools, excessive fine sediment in some spawning gravels, limited instream cover, and high summer stream temperatures in some areas (Morris 2003, 2004, 2005, White and Plumb; 2004, 2005, White and Cochrane 2005, Allen et al. 2006a, 2006b). Alders dominate riparian areas and limit long-term wood recruitment potential (Allen et al. 2006a; 2006b).

Actions:

- Protect functional riparian areas.
- Place LWD and other instream structure as appropriate to create pools, increase cover, and retain spawning gravels.
- Restore floodplain connectivity.
- Restore wetlands and other water holding capacity on the plateau through use of check dams and other methods.
- Establish conifers in riparian areas.
- Plant trees to reduce sediment input from banks.
- Implement measures to reduce cattle impacts to stream.

Buck Creek

Buck Creek provides potential spawning and rearing habitat for coho salmon and steelhead. Biologists believe that habitat quality is currently limited because of insufficient pools and spawning gravels, low summer flows, and unscreened agricultural diversion. No data currently supports these suppositions, except for that relating to temperature. Available data indicate that temperatures in Buck Creek meet WA state standards (White and Plumb 2004; White and Cochrane 2005).

Actions:

- Conduct habitat studies to identify limiting factors within Buck Creek.
- Place LWD and other instream structure, as appropriate, to create pools and retain spawning gravels.

- Assess instream flows and initiate actions to improve base flow.
- Screen agricultural diversion and improve passage at irrigation diversion.

Spring Creek

Spring Creek may provide productive habitat for reintroduced anadromous coho salmon and steelhead runs. Production potential is currently limited because of decreased habitat diversity and increased sediment. Biologists have not evaluated the factors limiting habitat in Spring Creek.

Actions:

- Conduct assessments to identify factors
- Protect or improve instream wood and functional riparian areas as necessary.
- Place LWD as appropriate.

6.3 Hatcheries

Artificial production may play a role in the recovery of salmon and steelhead populations in the White Salmon. The White Salmon Working Group has proposed a strategy to allow for the natural re-colonization of the White Salmon River after Condit Dam removal. As described above in section 6.1, biologists will evaluate the natural re-colonization of the newly accessible habitat and, if escapement and productivity goals are not being achieved, then the White Salmon Working Group or a new recovery planning body will consider additional strategies using artificial propagation. Innovative programs, such as those employed by the Yakima/Klickitat Fisheries Project, as described in the Klickitat Anadromous Fisheries Master Plan (YN 2008), would be consulted and appropriate methodologies adopted (Table 6-4).

6.4 Harvest-Related Strategies and Actions

WDFW will continue to manage non-tribal fisheries for selective fisheries that target marked hatchery salmon and steelhead, requiring the release of unmarked (wild) fish. Overall impacts are very low for these tributary fisheries, with impacts generally less than 5 percent of the naturally produced fish (NPCC 2004).

In 2009, the recreational fishing regulations in the White Salmon River prohibited the retention of unmarked Chinook salmon from April 1 to June 30 and closed the river to retention of all Chinook salmon ½ mile above the Hwy 14 Bridge from October 1 to December 31. Fishing regulations prohibit retention of wild (unmarked) coho salmon and unmarked Chinook jack salmon (Chinook salmon less than 24 inches) in the White Salmon River annually from July 1 to March 31. Fishing regulations also prohibit retention of chum salmon in tributary recreational fisheries.

Mainstem harvest will continue to be managed through the *U.S. v. Oregon* process, and will be subject to consultation with NMFS. Co-managers will incorporate enhanced public education and non-tribal fisheries along with new selective fisheries regulations to ensure understanding and compliance.

Treaty Indian fishing rights in the Columbia basin are under the continuing jurisdiction of the U.S. District Court for the District of Oregon in the case of *U.S. v. Oregon*, No. 68-513 (filed in 1968). The parties to *U.S. v. Oregon* are the United States acting through the Department of Interior (USFWS) and BIA and Department of Commerce (NMFS), the Warm Springs, Umatilla, Nez Perce, Yakama, and Shoshone-Bannock Tribes, and the states of Oregon, Washington, and Idaho. In *U.S. v. Oregon*, the Court affirmed that the treaties reserved for the tribes 50 percent of the harvestable surplus of fish destined to pass through their usual and accustomed fishing areas.

A new *U.S. v. Oregon* Management Agreement has been completed, and NMFS has completed a section 7 Biological Opinion addressing the impacts of the fisheries management action and hatchery production in the new agreement (NMFS 2008c). The new management agreement will cover CR fisheries management and hatchery production actions from 2008 to 2017.

During the last 10-15 years, *U.S. v. Oregon*, the CR Fish Management Plan and successor agreements that contain restraints on the fisheries necessitated by ESA listings have managed harvest regulations. The agreements quantify and allocate between tribal and non-tribal fishing subject to ESA-imposed constraints for listed species (Table 6-4).

6.5 Hydro-Related Strategies and Actions

Actions to address out-of-watershed hydro-related limiting factors and threats are included in the recently released 2008 FCRPS Biological Opinion (NMFS 2008b). (Available at https://pcts.nmfs.noaa.gov/pls/pcts-pub/pcts_upload.summary_list_biop?p_id=27149) (accessed April 11, 2012).

Within the White Salmon River watershed, removal of Condit Dam will achieve the goals of restoring flows to the 1.1-mile bypass reach; recruiting gravel to the lower 3 miles of river; and, in the long-term, restoring MCR steelhead spawning habitat. Removal will also provide unimpeded movement of adult and juvenile lower Columbia salmonids (fall Chinook salmon, coho, and chum salmon) in the White Salmon River (Table 6-4).

Table 6-4. Summary table addressing hatchery, harvest and hydrosystem-related recovery strategies and actions

Priority Strategies	Populations Affected and Addressed	Key Types of Actions	VSP Parameters Addressed	Potential Limiting Factors Addressed
Hatchery				
Restore natural production into historically utilized habitats, including blocked areas above the former Condit Dam	All populations	• Monitor escapement and natural re-colonization of historical habitat • Develop preferred option from reintroduction plan based on monitoring of natural re-colonization	All parameters	Lack of native stock
Harvest				
Manage harvest for low impact fisheries and reduce harvest-related adverse effects in those fisheries that have significant impacts	All populations	• Manage harvest for low impact fisheries • Adjust tributary harvest regulations in areas where harvest significantly impacts salmon and steelhead population growth	Abundance Productivity	Commercial, recreational, and tribal fisheries in ocean, mainstem CR and tributaries
Hydrosystem Issues and Mainstem Predation				
Maintain or improve hydropower operations and facilities at Bonneville Dam to enhance salmon and steelhead survival	All populations	• Maintain surface passage routes to improve juvenile passage at Bonneville Dam • Decrease water travel time during smolt outmigration • Improve operation of adult passage • Maintain high standards for adult fish passage at Bonneville Dam	All parameters	Hydrosystem development and operations in mainstem CR alter steelhead migration conditions and delay passage.
Reduce predation on, and competition between, salmonids	All populations	• Reduce predation by pinnipeds • Reduce predation by piscivores • Reduce predation by cormorants • Reduce predation by and relocate Caspian terns	Abundance Productivity	Hydrosystem development and operations in mainstem CR increase predation on, and competition between, salmonids.

7 Implementation and Cost Estimates

NMFS recognizes that there are significant uncertainties regarding expected future habitat conditions, that actions will need to restore habitat, and that actions require successful recolonization of salmonid populations in the White Salmon River watershed. NMFS is committed to an ongoing effort to address these uncertainties. This will require rigorous application of an adaptive management process that identifies key uncertainties, proposes competing hypotheses, and uses recovery actions and appropriate research and monitoring to test these hypotheses and adjust management accordingly.

Recovery is achievable only through the combined and coordinated actions of Federal and state agencies, tribes, and local governments, and with the participation of non-profit organizations, the business sector, and citizens. Collectively, NMFS refers to these parties as implementing partners. It will be essential that a collaborative implementation structure be set up to improve communication and work on a shared sense of priorities.

7.1 Implementation

The Washington Gorge Implementation Team (WAGIT) will coordinate implementation of the recovery plan for the White Salmon River watershed. The WAGIT is comprised of Klickitat County, the Yakama Nation, Washington Department of Ecology, Washington Department of Fish and Wildlife, the United States Geological Service, NMFS, the Central Klickitat and Underwood Conservation Districts, and various other stakeholders such as the Middle Columbia Regional Fisheries Enhancement Group. Representatives of the White Salmon Working Group are also participating on the WAGIT.

Implementation is being facilitated through the various existing programs in the area, including harvest management programs, the Yakama Nation Fisheries Program, Washington's Lead Entity Process, watershed planning and implementation processes initiated under state regulations and coordinated through the Klickitat County, various state and local habitat and watershed programs, and the various programs administered by the conservation districts. The WAGIT chose to draw upon and work within the many ongoing programs rather than developing a parallel, potentially duplicative process.

A balance between the biological benefit of a recovery action, its cost, and feasibility of implementation provides the basis for the WAGIT prioritization framework. Projects that address primary limiting factors, have high biological benefit to listed fish, are relatively inexpensive, and are feasible, receive highest funding priority. Projects with high cost, low biological benefit to listed fish species, and relatively low feasibility receive lowest funding priority.

Funding sources for salmon and steelhead recovery actions in the Columbia basin vary. They include:

- Pacific Coastal Salmon Recovery Fund (PCSRF) (states and tribes)
- Salmon Recovery Funding Board (SRFB) (a combination of PCSRF and Washington State funds)
- Columbia Basin Fish Accords
- Congressional appropriations (Federal agencies)

- State appropriations (state agencies)
- NPCC Fish and Wildlife program (states and tribes)
- Federal/state grants
- Non-profit organization programs and grants

7.2 Costs

NMFS, in coordination with the WAGIT and the White Salmon Working Group, provided cost estimates for implementing the White Salmon River Recovery Plan. The team developed cost estimates for a range of actions necessary to successfully reestablish anadromous fish populations in the White Salmon River watershed. There are numerous research, monitoring, and evaluation actions, specified in this Plan. Completed RM&E studies will help identify priority projects. In the absence of needed information, NMFS developed interim cost estimates for all potential recovery actions. NMFS and the area biologists estimated that RM&E actions will cost roughly $1,540,000 over a 5-year period. Chapter 8 provides further discussion of monitoring. Implementing PacifiCorp's decommissioning plans for Condit Dam is estimated at $0.9 to $1.1 million. Habitat actions related to the dam decommissioning could cost up to $15,100.000. The total cost over a 5-year period for restoring anadromous populations in the White Salmon River is estimated to be $16,781,000 (Table 7-1). More detailed information regarding these costs is provided in Appendix IV, White Salmon River Implementation Schedule: Summary of Actions and Potential Costs to Restore White Salmon River Anadromous Fish Populations and Their Habitat.

Table 7-1. Summary of potential costs to restore the White Salmon River fish populations and their habitat

ACTION CATEGORY	COST
Implementation of PacifiCorp's decommissioning plans	**$900,000 to 1,100,000**
RM&E	**$1,540,000**
Habitat Restoration and other actions	**15,100,000**
Hydrosystem and Mainstem Predation	**Not Estimated**
TOTAL	**$16,781,000**

The action categories listed in Appendix IV are derived from Chapter 6 Recovery Strategy and Actions. In many cases the specific actions provided in Appendix IV offer more detail than that described in Chapter 6. This is particularly true with regard to data collection and population monitoring. As discussed in Chapter 6, there is uncertainty regarding the primary factors that will limit the White Salmon populations in the long-term. Proposed data collection will fill those data gaps and provide direction for specific habitat restoration actions.

8 Monitoring, Research, and Evaluation for Adaptive Management

The various research and monitoring efforts proposed and underway in the White Salmon watershed regarding salmon and steelhead reintroduction, habitat restoration, and other activities require comprehensive empirical monitoring data on fish populations and habitat to identify appropriate project actions and strategies, select suitable sites and priority locations for actions, populate habitat/production capacity modeling efforts (such as EDT and All H's Analyzer [AHA]), and inform adaptive management for the salmonid recovery plan. Needed is additional information on fish distribution, abundance, productivity, habitat conditions, genetic diversity, pathogen levels, and other population parameters, as well as on population limiting factors. White Salmon recovery also requires a coordinated monitoring program to meet these various needs, as well as to help direct and evaluate the recovery effort.

8.1 Designing a Monitoring and Evaluation Program to Support Adaptive Management

Because of the length and complexity of the salmonid life cycle, there are many uncertainties involved in improving salmonid survival. To simply identify cause-and-effect relationships between any given management action and the characteristics of salmon populations can be a scientific challenge. It is essential to design a monitoring and evaluation program that will answer these basic questions: How will we know we are making progress? How will we get the information we need? How will we use the information in decision-making?

Designing an effective monitoring program for salmon recovery involves the following initial steps:

1. Clarify the questions regarding policy and management decision-making. Include the full ESU and the full salmonid life cycle.
2. Identify entity or entities responsible for coordinating development of this program.
3. Identify:
    - Which populations and associated limiting factors to monitor.
    - Metrics and indicators.
    - Frequency, distribution, and intensity of monitoring.
    - Tradeoffs and consequences of these choices.
4. Assess the degree to which existing monitoring programs are consistent with NMFS guidance.
5. Identify needed adjustments in existing programs, additional monitoring needs, and strategy for filling those needs.
6. Develop a data management plan (See Appendix B of *Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring*

Guidance (May 1, 2007) http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf (accessed April 11, 2012).

7. Prioritize research needs for critical uncertainties, testing assumptions, etc.
8. Identify entities responsible for implementation.

8.2 Adaptive Management

Adaptive management means taking an experimental approach to a complex task, making one's assumptions clear, and continuously evaluating them in the light of new information. Adaptive management works best when the design of performance data collection and evaluation methods helps the information managers make sound decisions. As outlined in the NMFS *Adaptive Management* guidance document, several types of monitoring are needed: 1) implementation and compliance monitoring, which is used to evaluate whether the recovery plan is being implemented; 2) status and trend monitoring, which assesses changes in the status of an ESU (or a DPS) and its component populations, as well as changes in status or significance of the threats to the ESU (or the DPS); 3) effectiveness monitoring, which tests hypotheses and determines (via research) whether an action is effective and should be continued. In addition, it's important to build research to illuminate the many unknowns in salmon recovery - the "critical uncertainties" - that make management decisions all the more difficult.

NMFS' guidance document presents a decision framework (Figure 8-1) that can guide the design of a RM&E plan. The framework contains: 1) questions regarding ESU/DPS status (biological viability criteria); 2) questions regarding statutory listing factors and factors limiting recovery (limiting factor and threats criteria). Evaluating a species for potential delisting requires an explicit analysis of both types of criteria.

The guidance document contains a more detailed discussion of the framework and identifies the specific questions necessary to evaluate ESU/DPS status. These specific questions take the form of a series of decision-question sets that address the status and change in status of a salmonid DPS and the risks posed by threats to the DPS. NMFS designed the decision-question sets to elicit the information it needs to make delisting decisions. For recovery planners, the framework can guide future decisions about management strategies and actions aimed at achieving recovery goals.

The White Salmon monitoring and evaluation program will build on existing programs designed for monitoring tributary habitat in the White Salmon. The White Salmon monitoring and evaluation program will provide 1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed; 2) a plan for tracking such metrics and indicators; 3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the Plan's goals.

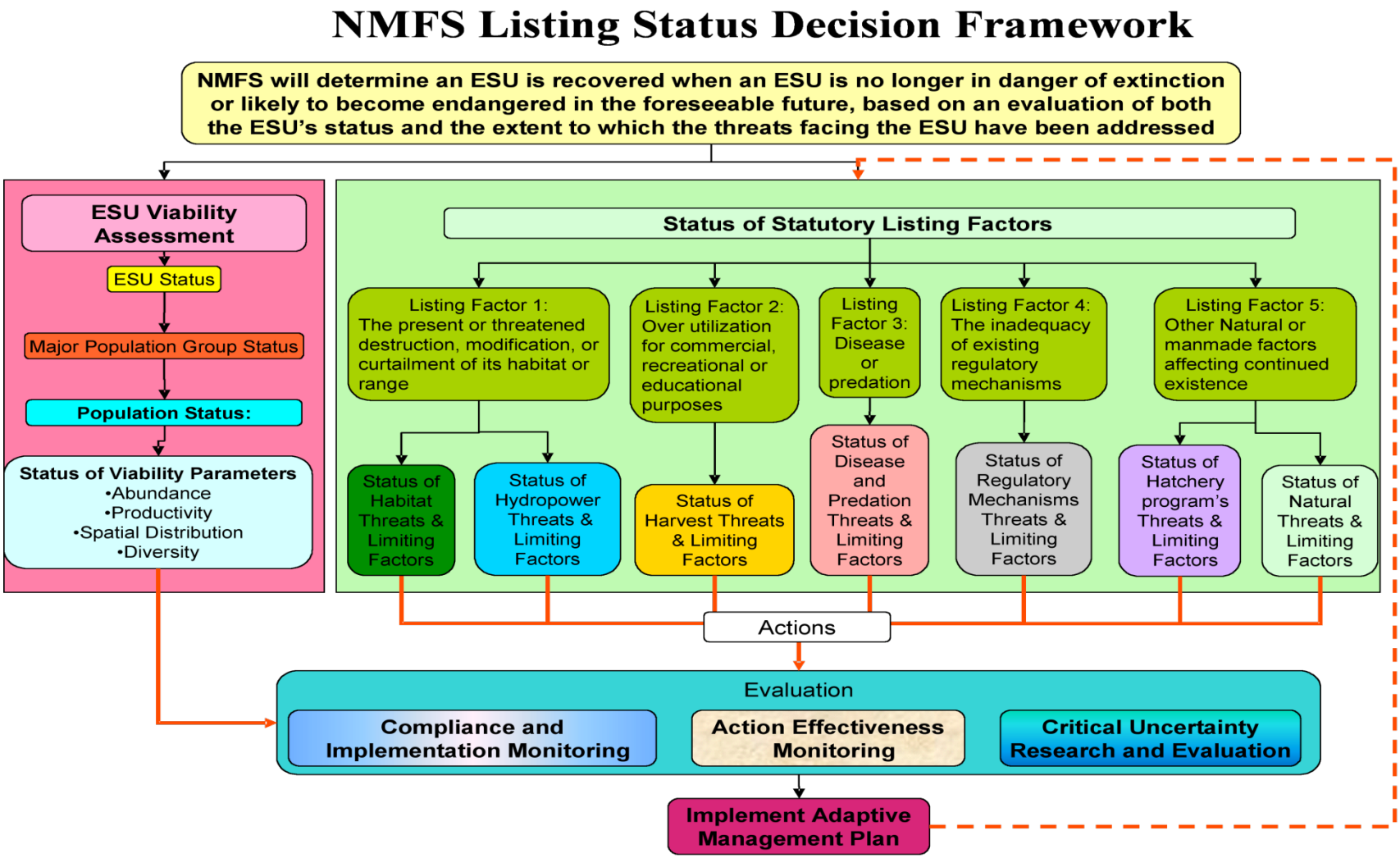


Figure 8-1. NMFS Listing Status Decision Framework

8.3 Critical Uncertainties

Data gaps important to recovery can be divided into two major categories: 1) those that deal with critical uncertainties; 2) gaps in knowledge about the linkages between specific actions and their effects on habitat factors and VSP parameters. Monitoring and evaluation will fill some of the data gaps; research will fill others.

Critical uncertainties, the unknown aspects of environmental conditions vital to salmonid survival, are a major focus of the RM&E program. To establish linkages between specific actions and resultant environmental effects will require monitoring. Those linkages are complex and often not well understood. Understanding them requires input from experts from various fields. It is important that the actions recommended in the Plan to benefit listed fish species in the White Salmon watershed be reviewed by fish ecologists, geologists, hydrologists, and other experts familiar with the recovery region.

The Plan expects that specific benchmark values for the VSP parameters will be refined during Plan implementation based on new information that addresses current uncertainties.

There are numerous out-of-basin uncertainties. The geographic areas that constitute the multiple ESU/DPSs encompass a large part of northern Oregon and a large part of southern Washington draining into the Columbia River. There are multiple populations across species. This context is significant in terms of uncertainties:

- Under the ESA, successful recovery of listed species as defined by NMFS requires achieving specific levels of productivity for populations within the entire ESU/DPS, not only acceptable productivity within any single basin that is a part of the ESU/DPS. Local communities in different watersheds/basins across local and state boundaries are dependent upon each other for successful delisting of these species.
- Of the seven necessary components of an ESA recovery plan, only three are the responsibility of in-basin parties - for which there is currently no collaborative governing board. The other components (e.g., hydropower operations, harvest, hatcheries, macro-economics, estuarine conditions), though significant to impacts on overall mortality, involve factors that are outside of the White Salmon watershed and actions taken within the watershed do not directly these factors. To measure the increases/decreases in productivity of the target populations before they migrate out of the watershed will require monitoring.

8.3.1 Research

As noted earlier, unknown aspects of environmental conditions vital to salmonid survival are termed “critical uncertainties.” Critical uncertainty research targets specific issues that constrain effective recovery plan implementation. This includes evaluations of cause-and-effect relationships between fish, limiting factors and actions that address specific threats related to limiting factors. Listed below are research actions to assess the effects of the uncertainties on recovery of listed fish species in the White Salmon watershed. Research actions address both in-basin and out-of-basin factors and are not all-inclusive. The

following lists in-watershed and out-of-watershed research needs. This list derives from a longer list identifying potential research needs for other basins within the ESUs and DPS.

8.3.2 In-Watershed Research Needs

- Determine fish abundance, origin, and production data after decommissioning of Condit Dam.
- Determine mainstem restoration needs after PacifiCorp's decommissioning plans have been implemented.
- Conduct habitat/population assessment work in Buck Creek.
- Track sediment downstream of Buck Creek through time.
- Monitor water quality after dam decommissioning.
- Assess impacts of dam removal on mainstem and tributary mouths above project area.
- Address potential issues at in-lieu fishing site after dam decommissioning.
- The White Salmon River is a thermal refuge. How important is this? What impact will this have on salmon and steelhead? Steelhead move into the White Salmon River to seek cold water refuge when mainstem Columbia River temperatures increase. What impact has dam-removal had on this condition?
- Increase understanding of linkages between physical and biological processes so that managers can predict changes in survival and productivity in response to selected recovery actions.
- Test assumptions and sensitivity of EDT and other model runs.
- Determine relative performance (survival and productivity) and reproductive success of naturally producing species.
- Assess population structure.
- Determine the effects of exotic species on recovery and the feasibility of actions to eradicate or control numbers of exotic species.
- Improve the understanding of the range of interactions between resident and anadromous forms of *O. mykiss*. The nature of the relationship is inherently complex and needs further evaluation, especially as recolonization begins to occur.
- Investigate instream flow needs for the mainstem White Salmon and tributaries that will support anadromous fish.

8.3.3 Out-of-Watershed Research Needs

- Monitor harvest levels.
- Develop better methods to estimate harvest of naturally produced salmon and steelhead and indirect harvest mortalities in freshwater and ocean fisheries.

- Assess the interactions between hatchery and naturally produced salmon and steelhead.
- Assess if hatchery programs increase the incidence of disease and predation on naturally produced fish.
- Evaluate increased predation risks from native and non-native fish, birds, and mammals.

These should be coordinated with NOAA's CR Estuary Recovery Plan Module (NMFS 2007) and the 2008 FCRPS Biological Opinion (NMFS 2008c).

8.4 Monitoring

The Plan includes direction for RM&E to: define unknown population characteristics, contribute to regional monitoring efforts, better direct efforts within the watershed, and assess the effectiveness of future actions.

Research and monitoring are designed to test implementation, validation, status/trend, and effectiveness. Implementation monitoring determines if the appropriate entities implemented the planned actions as intended and whether all implementation objectives are on schedule (section 8.1, Designing a Monitoring and Evaluation program to Support Adaptive Management). Status/trend monitoring determines the current conditions (status) of the populations and their habitats and their changes over time (section 8.2, Adaptive Management). Effectiveness monitoring focuses on whether the recovery actions changed the environment and/or the VSP parameters (section 8.3, Critical Uncertainties). Validation monitoring determines whether the fundamental ecological assumptions underlying the recovery plans are true. Prominent among these assumptions are the effects of specific environmental conditions on survival and abundance of listed fish species embodied in the EDT model. Researchers will determine which assumptions need testing once recovery planners fill the critical data gaps (section 8.3, Critical Uncertainties).

Conditions outside the watershed will affect and inform actions, research, and monitoring within the watershed. Out-of-basin conditions do and will have a significant effect on the success of recovery of species within the watershed. These factors include commercial harvest, sport and tribal harvest, conditions in the mainstem CR (including hydroelectric operations), and conditions in the estuary and ocean including short and longer term cycles in ocean conditions. The regional RM&E program developed under the FCRPS Biological Opinion will measure status, trends, and effectiveness of actions in this area.

A recently formed multi-agency Condit Technical Working Group (now White Salmon Working Group) met in early 2007 to discuss RM&E issues (and actions to resolve them) in light of the proposed removal of Condit Dam. The section "In-Watershed Research Needs" (below) the RM&E questions drafted during this meeting are detailed further.

Key Question #1: What is the source of colonizing salmon and steelhead?

Collect genetic samples after dam decommissioning and compare with samples collected prior to dam removal using genetic analysis.

Key Question #2: Has the abundance and origin of salmon, steelhead, and bull trout spawners changed between pre- and post- dam removal?

Compare pre-removal abundance of spring Chinook salmon, fall Chinook salmon, steelhead, and coho salmon with abundance post dam removal.

Key Question #3: Has smolt production increased after dam removal?

Compare smolt estimates pre-dam removal for Chinook salmon fry, and coho, Chinook salmon, and steelhead smolts (USGS) with smolt population estimates after dam removal.

Key Question #4: Has the habitat changed after dam removal?

Compare bathymetric surveys below Condit in the early 1990s with post-removal surveys. Conduct cross-sectional profiles just above reservoir and near mouth to document down-cutting and sediment transport.

Described below is a general framework for monitoring within the White Salmon watershed.

8.4.1 Implementation Monitoring

Effective RM&E requires implementation and compliance monitoring checks to determine whether action entities carried out the activities as planned and whether action entities met specified criteria as a direct result of an implemented action. Scientists will monitor recovery actions within the White Salmon watershed to assess whether action entities implemented the actions as planned. This monitoring will consist of an administrative review and will not require environmental or biological measurements.

Implementation monitoring will address the types, numbers, and locations of actions implemented and how much area or stream length each action affected. Indicators for implementation monitoring will include visual inspections, photographs, and field notes on numbers, location, quality, and area affected by an action. For example, if fencing is planned for 20 miles of stream corridor to keep livestock off the stream banks so that riparian vegetation will rebound, implementation monitoring would verify the presence of the fence. Compliance monitoring would take note of the presence or absence of livestock in the fenced-off area.

Comparing field notes with the specifications in the plans or proposals (detailed descriptions of engineering and design criteria) will determine success. Thus, design plans and/or proposals will serve as the benchmark for implementation monitoring. Evaluations will describe in detail any deviations from specified engineering and design criteria.

8.4.2 Status/Trend Monitoring

Status and trend monitoring is a compilation of data based descriptions of existing conditions. To be useful in decision-making, a scientist reduces the raw data, or metrics, to a more directly applicable form or indicator. For example, if the question is "What is the annual spawning population-size of steelhead in the White Salmon River?" The indicator would be total spawning numbers of steelhead over one season for the entire river basin. The metric, or directly measured thing, however, would be something quite different, perhaps

steelhead redds sighted on weekly passes over known spawning grounds. Thus, a scientist would process the metric to translate it from the metric data type (e.g., redds) into the indicator data type (e.g., spawners) and then summarize to generate the indicator required (e.g., from a list of weekly counts on spawning grounds to an annual total for the watershed).

A future collaborative board directing implementation will develop a program to monitor the status and trend of salmon and steelhead and their habitats throughout the White Salmon watershed. The program will utilize guidelines developed in the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) and the Collaborative System-wide Monitoring and Evaluation Project (CSMEP).

8.4.3 Effectiveness Monitoring

Effectiveness monitoring specifically addresses cause-and-effect questions. Demonstrating the direct and indirect impact of management actions requires supporting all steps in a logical chain that connects the action to its expected impact. This chain is rarely short and usually contains several hypotheses. For this reason, it's better to build the effectiveness monitoring into the recovery action strategies with, for example, pilot-scale tests or other methods carefully thought out beforehand.

Not all recovery actions the Plan recommends need monitoring to determine effectiveness. However, it is important that scientists assess a sufficient number of replicates of each "type" of action to assess effectiveness. To the extent possible, monitoring for recovery action effectiveness will use the Before-After-Control-Impact design with stratified random sampling, as described in the Comprehensive Statewide Monitoring Strategy (Monitoring Oversight Committee 2002). This strategy describes in detail the approach, indicators, and protocols needed to assess effectiveness of habitat restoration classes. It is critically important to coordinate the effectiveness monitoring programs with status/trend monitoring and effectiveness monitoring within the hydro sector.

Monitoring and evaluation will only provide the answers to the questions the RM&E designs intended to address. They do not provide the framework for revising questions that are ill posed. Evaluating the assumptions upon which the recovery planners built their strategy or incorporated learning into future action and strategy decisions is the role of adaptive management.

8.5 Consistency with Other Monitoring Programs

This recovery plan will utilize existing monitoring programs to evaluate the status/trend and effectiveness of recovery actions within the White Salmon watershed. Specifically, this approach will incorporate strategies, indicators, and protocols described in the Yakima/Klickitat Fisheries Project, the upper Columbia Monitoring Strategy, the Comprehensive Statewide Monitoring Strategy, and CSMEP. The development of other regional monitoring programs may result in modifications to the monitoring programs used in the White Salmon watershed. These other programs, in various states of development, include such approaches as PNAMP. As these programs develop more fully, they will provide guidance on valid sampling and statistical designs, measuring protocols, and data management. Scientists may use this information to refine and improve the existing

monitoring and evaluation programs in the White Salmon watershed. The intent is to make monitoring and evaluation programs in the White Salmon watershed consistent with programs throughout the Columbia basin as well as the ESUs and DPS.

8.6 Coordination

Many entities have been or will be implementing recovery actions within and downstream of the White Salmon watershed. Monitoring programs to coordinate with include:

- Yakima/Klickitat Fisheries project
- YN Monitoring
- NOAA Fisheries RM&E program
- Washington SRFB program
- PACFISH/INFISH Monitoring program
- Pacific Northwest Interagency Regional Monitoring program
- USFWS, USGS, and Bureau of Reclamation (BOR), monitoring programs
- WDFW and Washington Department of Ecology monitoring programs
- Washington Department of Ecology Watershed Assessment and Management Process (Revised Code of Washington (RCW) 90.82)
- Local UCD monitoring

It is critical that recovery planners consult with these programs to emphasize utility, reduce redundancy, increase efficiency, and minimize costs.

8.7 Evaluation Schedule

While the White Salmon watershed currently has no collaborative regional board guiding work, a regional board for the Washington Gorge Management Unit could develop as a follow-up to recovery planning. An appropriate first check-in for the watershed is 3 years from the adoption of the Plan. At this time, the board or co-managers should review efforts within the watershed - whether or not they have obtained funding and initiated actions. At years 5, 8, and 12 further evaluations should occur in order to coordinate with other watersheds in the ESUs and the middle Columbia Steelhead DPS. Reviews at this time should start with funding and implementation effectiveness. If funding and implementation have taken place previously, the RM&E program should review their effectiveness and measure progress toward the overall implementation of projects within White Salmon. The evaluation should place progress, or the lack thereof, within context of all the ESUs and the DPS.

The first major step in the adaptive management program is to obtain 5-year implementation schedules from each of the partners that describe the tasks, schedules, priorities, and estimated cost to implement the recovery actions. The RM&E program will request that each of the Federal and state agencies, tribal and local governments, and non-governmental

partners prepare an implementation schedule for their recovery actions. A regional implementation schedule covering the entire White Salmon Management Unit will combine these individual schedules. The recovery partners will complete their initial schedules in the summer of 2010; they will prepare new schedules annually incorporating changes or modifications based on implementation and effectiveness evaluations. NOAA Fisheries 5-year ESA status reviews should coordinated with additional evaluations of the status of viability attributes limiting factors and new information critical uncertainties. The White Salmon Recovery Plan should incorporate the results of these programs into adaptive management and coordinate with other middle Columbia steelhead recovery plans, the recovery plan estuary, and harvest modules for the CR, as well as the 2008 FCRPS Biological Opinion.

8.8 Monitoring and Evaluation Plan

The information in this chapter provides a framework for the development of a salmonid RM&E and adaptive management plan for the White Salmon Basin. When NMFS finalizes the recovery plan's goals and objectives, a process will begin to fully develop a RM&E plan with the White Salmon Working Group and append it to the recovery plan when the recovery plan is completed. A multi-agency salmonid reintroduction plan for the White Salmon River will rely heavily on results of research guided by ongoing monitoring and evaluation.

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Appendix I. Options for Salmon and Steelhead Reintroduction

The following are reintroduction plans for salmon and steelhead in the White Salmon River that were developed by the White Salmon Working Group, made up of Federal, state, and tribal fisheries managers, as well as representatives of the PacifiCorp (Condit Dam operators). The White Salmon Working Group developed a number of options for the reintroduction of salmon and steelhead into the White Salmon River in anticipation of the removal of Condit Dam in the fall of 2009. Each option developed for the various salmon and steelhead populations includes a description of the biological basis for the approach, operational and maintenance needs, and the monitoring and evaluation needs to support the approach. Each of the Plans and assorted options that were developed are listed below, with the preferred option highlighted in gray.

Tule Fall Chinook salmon

Salvage Effort Options within the White Salmon River in Preparation of Removal of Condit Dam.

1. Salvage adipose present CWT-negative tule fall Chinook salmon from White Salmon River in fall 2010 to start tule fall Chinook salmon restoration. Eggs collected and reared at Spring Creek NFH, juveniles acclimated and released at White Salmon Ponds.

a. Biological Basis

   i. Would emphasize collection of adult returns that presumably are natural progeny from previous spawning populations in the White Salmon.

   ii. The mass marking protocol used at Spring Creek NFH would allow for identification of "wild" fish on the spawning grounds.

      1. Hatchery fish would be either adipose-fin clipped or have a CWT present.

      2. Wild fish would have adipose-fins present and no CWT.

b. O&M (Operation and Maintenance) Needs

   i. Temporary weir construction at White Salmon Ponds.

      1. A salvage effort with fish wheel or active adult seining in Lower River to capture adipose present tule fall Chinook salmon could also be used in lieu of or in addition to weir.

         (a) Several options should be discussed for what efforts might be fiscally and logistically possible.

      2. New screens would be needed at the intake structure to comply with NOAA Fisheries or a waiver would be required to operate the ponds and weir during adult collections.

3. Potential need to coordinate with Condit Dam operations should flow manipulation need to occur for selected capture method.

ii. Eggs reared at Spring Creek NFH and transferred for acclimation at White Salmon Ponds for release in April or May per rotary trap timing of tule fall Chinook salmon.

1. Ponds need to be watered up and ready by spring following dam removal to be used for acclimation.

2. Potential upriver or alternative acclimation strategies could be used if White Salmon Ponds are not a viable option.

iii. Program Size

1. 1996 Columbia Basin Fish and Wildlife Authority (CBFWA) Document states 32,000 0+ juveniles for production and release. This translates into about 58 adults that will return based on SCNFH escapement estimates.

2. NMFS Draft White Salmon Recovery Plan states abundance recovery goal of 900 adults (TRT recommendations, pg 105).

3. White Salmon Subbasin Plan (using EDT analysis) estimates 792-995 for abundance estimation from historical through removal with PFC.

4. Based on adult escapement estimates for White Salmon, 500 to 600 adults might "fill out" escapement. The production goals would correlate to annual releases of 275,000 to 330,000.

5. Capacity at White Salmon ponds would be 300,000 for release.

iv. Need to revise HGMP from Spring Creek NFH

1. Would encompass tules and other stocks that may be acclimated at ponds (pending workgroup decisions).

c. RM&E Needs

i. Specific juvenile tagging of these fish is also needed to determine survival rates and evaluate the salvage action.

ii. Genetic analysis of adults collected for salvage effort in 2010.

1. Needed to properly assess success of salvage effort and also act as a baseline for monitoring hatchery/wild fish interactions on the spawning grounds for future years.

iii. Continuation of rotary trapping and genetic analysis to determine production of juveniles.

iv. Expansion of WDFW carcass surveys into areas above Condit dam in 2010 and beyond.

v. Some decision process to end production based on rotary trapping results of successful spawning abundance or on wild adult escapement estimates (might be easier to estimate).

2. Salvage adipose present tule fall Chinook salmon returning to Spring Creek NFH in fall 2009 to start restoration. Eggs collected and reared at Spring Creek NFH, with juveniles acclimated and released at White Salmon Ponds.

   a. Biological Basis

      i. Would emphasize collection of adult returns that presumably are natural progeny from previous spawning populations in the White Salmon.

      ii. Annual returns to Spring Creek NFH have some components that are presumed to be naturally produced fish.

         1. Fish that have their adipose fin and do not have a CWT.

         2. This would need to be verified by analysis of CWT return data in combination with scale analysis between CWT/adipose fin clipped fish and "wild" interceptions at the hatchery.

   b. O&M Needs

      i. Eggs reared at SCNFH and transferred for acclimation at White Salmon Ponds for release in April or May per rotary trap timing of tule fall Chinook salmon

         1. Ponds need to be watered up and ready by spring 2011, this should be 2010 if we are collecting in 2009, if going to be used for acclimation.

         2. Would need to modify screens or get a waiver from NOAA Fisheries.

         3. Potential upriver or alternative acclimation strategies could be used if White Salmon Ponds are not a viable option.

      ii. Program Size

         1. 1996 CBFWA Document states 32,000 0 + juveniles for production and release. This translates into about 58 adults that will return based on SCNFH escapement estimates.

         2. NMFS Draft White Salmon Recovery Plan states abundance recovery goal of 900 adults (TRT recommendations, pg 105).

         3. White Salmon Subbasin Plan (using EDT analysis) estimates 792-995 for abundance estimation from historical through removal with properly functioning conditions.

         4. Based on adult escapement estimates for White Salmon, 500 to 600 adults might "fill out" escapement. The production goals would correlate to annual releases of 275,000 to 330,000.

5. Capacity at White Salmon ponds would be 300,000 for release.

iii. Need to revise HGMP from Spring Creek NFH.

1. Would encompass tules and other stocks that may be acclimated at ponds (pending workgroup decisions).

c. RM&E Needs

i. Specific juvenile tagging of these fish is also needed to determine survival rates and evaluate the salvage action.

ii. Genetic analysis of adults collected for salvage effort in 2009.

1. Needed to properly assess success of salvage effort and also act as a baseline for monitoring hatchery/wild fish interactions on the spawning grounds for future years.

iii. Expansion of WDFW carcass surveys into areas above Condit dam in 2010 and beyond.

iv. Continuation of rotary trapping and genetic analysis to determine natural production of juveniles.

v. Some decision process to end production based on rotary trapping results of successful spawning abundance or on wild adult escapement estimates (might be easier to estimate).

3. No salvage effort in the White Salmon or at SCNFH

a. Biological Basis

i. Assumes natural colonization in the future.

ii. Would assume that sediment movement after dam removal would be large and allow for successful natural colonization immediately.

b. O&M Needs

i. None at SCNFH

c. RM&E Needs

i. Continuation of rotary trapping and genetic analysis to determine natural production of juveniles.

ii. Expansion of WDFW carcass surveys into areas above Condit dam in 2010 and beyond.

4. Outplant adults, adipose present, in 2010 above Condit Dam prior to removal.

a. Biological Basis

i. Assumes natural colonization and allows some spawning to occur above Condit Dam prior to removal.

ii. Would assume that sediment movement after dam removal would be large and allow for successful natural colonization in later years.

iii. Could be done in conjunction with any of the previous actions or for a number of years to allow for natural colonization.

b. O&M Needs

i. Radio-tagging and Peterson disc tagging of adults to determine movement to White Salmon.

c. RM&E Needs

i. Continuation of rotary trapping and genetic analysis to determine production of juveniles.

ii. Expansion of existing carcass surveys conducted by WDFW to monitor spawning above Condit Dam during 2009 and in 2010.

Spring Chinook salmon

1. Natural re-colonization - no active reintroduction efforts from outside sources.

a. Biological Basis

i. Probably very small number of returning native adults - may not be sufficient number to restart population.

ii. Concerns about Carson fish on spawning grounds?

b. O&M Needs - little to none

c. RM&E Needs

i. Monitor any natural spawner escapement.

ii. Monitor Carson fish on spawning grounds.

iii. Monitor smolt production.

2. Wild Klickitat spring Chinook salmon as brood source for juvenile release into the White Salmon River. Eggs collected and reared at Klickitat Hatchery, juveniles acclimated and released at White Salmon Ponds.

a. Biological Basis

i. Would emphasize collection of wild Chinook salmon from locally adjacent watershed, with similar geomorphologic characteristics and flow regime.

ii. No mass marking to minimize harvest to return as many spawners to White Salmon River as possible.

1. Hatchery fish would have unique CWT if determined that carcasses survey would be productive. More important to CWT after natural production is established.
2. Use PIT-tagging. Limited Wild fish would have adipose fins present and no CWT.

b. O&M Needs

i. New improved broodstock collection facility at Lyle Falls Fishway (~3 years out).

ii. Isolated spawning and rearing at Klickitat Hatchery - several options should be discussed for what efforts might be fiscally and logistically possible.

iii. White Salmon Pond rehabilitation and O&M.

iv. Juvenile transport at fry or smolt stage.

c. RM&E Needs

i. Monitor natural and hatchery escapement to spawning grounds.

ii. Monitoring natural escapement in Klickitat River (relatively low in recent years) and any impacts to natural population from broodstock collection.

3. Klickitat Hatchery spring Chinook salmon as brood source for juvenile release into upper White Salmon River, starting in spring 2010 (from Klickitat Hatchery thinning release or other surplus juveniles).

a. Biological Basis

i. Would emphasize use of hatchery Chinook salmon from locally adjacent watershed.

ii. Possible concerns about genetic mixing in Klickitat Hatchery stock of stream- and ocean-type Chinook salmon (see c.ii. below).

b. O&M Needs

i. Isolated spawning and rearing at Klickitat Hatchery - several options should be discussed for what efforts might be fiscally and logistically possible.

ii. Upper White Salmon release site identified/developed and O&M.

iii. Direct stream release locations identified/developed.

c. RM&E Needs

i. Fish Health monitoring (BKD concerns).

ii. Assessment of possible effects of use of genetically mixed Klickitat Hatchery stock (evidence of possible broodstock mixing of stream-type [spring-run] and ocean-type [summer-run] in Klickitat Hatchery stock).

4. Klickitat Hatchery integrated stock spring Chinook salmon as brood source for juvenile release into White Salmon River, in future years (broodstock source would be hatchery-reared offspring of wild fish).
    a. Biological Basis
        i. Would emphasize use of integrated stock Chinook salmon from locally adjacent watershed.
        ii. May alleviate concerns of broodstock mining effects on Klickitat wild population (pending success of program at Klickitat Hatchery).
        iii. Would likely alleviate concerns regarding use of current Klickitat Hatchery stock due to possible mixing of stream- and ocean-type Chinook salmon (see 3.c.ii above).
    b. O&M Needs - similar to Option 3 above.
    c. RM&E Needs - similar to Option 3 above (except for 3.c.ii).
5. Transport surplus Klickitat Hatchery adults to White Salmon starting in fall 2010.
    a. Biological Basis
        i. May be precluded by disease concerns resulting from out-of-basin transfer of adult fish.
        ii. Possible concerns about genetic mixing in Klickitat Hatchery stock of stream- and ocean-type Chinook salmon (see 3.c.ii. above).
    b. O&M Needs
        i. Trucking O&M.
        ii. Racking in of transported broodstock.
    c. RM&E Needs
        i. Radio-telemetry study.
        ii. Assessment of possible genetic effects (see 3.c.ii. above).
6. Trap and transport Klickitat wild adults to White Salmon.
    a. Biological Basis
        i. May be precluded by disease concerns resulting from out-of-basin transfer of adult fish.
    b. O&M Needs
        i. Trucking O&M.
        ii. Racking in of transported broodstock.

c. RM&E Needs

i. Monitor any natural re-colonization in interim (concerns about Carson fish?)

ii. Radio-telemetry study.

iii. Monitoring natural escapement in Klickitat River (relatively low in recent years) and any impacts to natural population from adult trap and transport.

7. Monitor natural escapement and production for 4-5 years then evaluate need and suitability of Option 4.

a. Biological Basis

i. Would determine if sufficient number of returning adults to restart population.

ii. Concerns about Carson fish on spawning grounds?

b. O&M Needs - little to none (unless Option 4 initiated).

c. RM&E Needs

i. Monitor any natural spawner escapement.

ii. Monitor Carson fish on spawning grounds.

iii. Monitor smolt production.

Coho salmon

1. Natural re-colonization - no reintroduction efforts from outside sources.

a. Biological Basis

i. Sufficient number of returning adults to restart population?

ii. Identification of coho benefits from EDT modeling efforts.

b. O&M Needs - little to none

c. RM&E Needs

i. Monitor natural spawner escapement.

ii. Monitor smolt production.

2. Juveniles from Washougal and/or Bonneville/Cascade hatcheries released into White Salmon River.

a. Biological Basis

i. Would use LCR coho stock for brood source (Washougal Hatchery, Lewis River, Type N, and/or Tanner Creek).

b. O&M Needs

i. Existing facilities at Washougal, Bonneville and Cascade hatcheries.

ii. For possible acclimation - White Salmon Pond rehabilitation and O&M.

iii. Juvenile transport at fry or smolt stage.

c. RM&E Needs

i. Monitor natural and hatchery escapement to spawning grounds.

ii. Monitor natural production.

iii. Fish health monitoring.

3. Collection of wild adult broodstock in Klickitat River with spawning and rearing at hatchery facility and juvenile release in White Salmon River.

a. Biological Basis

i. Would use nearby wild broodstock source.

b. O&M Needs

i. Identify suitable hatchery facilities for spawning and rearing.

ii. Adult capture facility at Lyle Falls Fishway on Klickitat River.

iii. For possible acclimation - White Salmon Pond rehabilitation and O&M.

iv. Juvenile transport at fry or smolt stage.

c. RM&E Needs

i. Monitor natural and hatchery escapement to spawning grounds.

ii. Monitor natural production.

iii. Fish health monitoring.

4. Collection of wild adult broodstock in White Salmon River with spawning and rearing at hatchery facility and juvenile release in White Salmon River.

a. Biological Basis

i. Would use local wild broodstock source.

b. O&M Needs

i. Identify suitable hatchery facilities for spawning and rearing.

ii. Adult capture facility - Weir or White Salmon Ponds rehabilitation.

iii. For possible acclimation - White Salmon Pond rehabilitation and O&M.

iv. Juvenile transport at fry or smolt stage.

c. RM&E Needs

i. Monitor natural and hatchery escapement to spawning grounds.

ii. Monitor natural production.

iii. Fish health monitoring.

5. Monitor natural escapement and production for 4-5 years then evaluate need and suitability of Options 2, 3 or 4.

a. Biological Basis

i. Would determine if sufficient number of returning adults to restart population.

ii. Identification of coho benefits from EDT modeling efforts.

b. O&M Needs - little to none (unless Options 2, 3, or 4 initiated).

c. RM&E Needs

i. Monitor natural spawner escapement.

ii. Monitor smolt production.

Chum salmon

1. Natural re-colonization - no reintroduction efforts from outside sources.

a. Biological Basis

i. Allows for natural colonization from populations within or below Bonneville pool.

b. O&M Needs

c. RM&E Needs

i. Continuation of either annual or every nth year chum surveys using revised chum specific "Patch" analysis or remote sensing techniques to monitor re-colonization efforts.

2. Active adult outplanting in years after Condit Dam Removal.

a. Biological Basis

i. Decreases timeframe of re-colonization and potentially provides better opportunity for multiple pairs of chum salmon to spawn in White Salmon.

ii. Most likely chum salmon are extirpated from White Salmon and chances for spawning to be occurring presently seem very unlikely.

iii. Accelerates building of chum population in White Salmon.

b. O&M Needs

i. Adults would have to be trapped in Bonneville Dam fishways or below Bonneville Dam (Ives Island, Duncan, Hardy and/or Multnomah Creek deltas) and trucked to release point in White Salmon River.

ii. Appropriate chum spawning channels could be constructed in suitable habitat within lower White Salmon River and adults transported into these channels.

c. RM&E Needs

i. Begin annual or every nth year surveys using chum specific "Patch analysis to monitor population dynamics.

ii. Identification of donor populations and determine both genetic and population fitness of these populations. (Below Bonneville stocks appear to be genetically best suited, and most easily obtained.)

iii. Identification of suitable spawning/outplanting locations and juvenile rearing habitat within White Salmon and lower tributaries.

iv. Potential PIT-tagging or Radio-tracking to determine spawning ground distribution and success or utilize remote sensing techniques.

3. Active stocking of juvenile chum salmon or outplanting of eggs in egg baskets and hatch boxes via WDFW's Washougal Hatchery or Willard NFH.

a. Biological Basis

i. Decreases timeframe of re-colonization and potentially provides better opportunity than natural re-colonization.

ii. O&M needs - yet to be determined but could involve infrastructure needs to Willard or Washougal hatcheries in addition to fish culture needs.

b. RM&E Needs

i. Continuation of either annual or every nth year surveys using chum specific "Patch analysis to monitor population dynamics.

ii. Identification of donor populations and determine both genetic and population fitness of these populations. (Bonneville fishway and or below Bonneville stocks appear most suitable and most easily obtained).

iii. Identification of suitable stocking locations and juvenile rearing habitat within the White Salmon River and lower tributaries.

iv. Potential PIT-tagging or Radio-tracking to determine distribution, timing and movement of chum salmon juveniles.

4. Initiate temporary hatchery program for chum salmon using existing USFWS hatcheries for subsequent outplanting using only chum captured at Bonneville Dam.

a. Biological Basis

i. Decrease risk to downstream donor stocks whose numbers are annually declining.

ii. Uses parent stock of chum salmon with fidelity to the Bonneville Reservoir and possible the White Salmon River.

iii. Decreases timeframe of re-colonization.

b. O&M Needs

i. Adults would have to be trapped in Bonneville Dam fishways.

ii. Adults would be held and spawned in Service Hatcheries.

iii. Eggs or juveniles would be outplanted in suitable habitat.

c. RM&E Needs

i. Survey and identify suitable habitats prior to outplanting.

ii. Evaluate success of any outplanted eggs.

iii. Continuation of either annual or every nth year surveys using chum specific "Patch analysis to monitor population dynamics.

iv. Potential PIT-tagging or Radio-tracking to determine distribution, timing and movement of returning adult chum salmon passing Bonneville Dam.

Steelhead

There are indications that the population of *O. mykiss* in the White Salmon River above Condit Dam is still producing smolts even though anadromy has been eliminated since the construction of Condit Dam and the end of passage in 1913. Pre-removal monitoring in the White Salmon River above Condit Dam has identified *O. mykiss* juveniles displaying smolt behavior and morphology, and PIT-tagged juveniles have been detected passing Bonneville Dam with one being recovered at the tern colony on East Sand Island (B. Allen, personal communication, 2007). In addition, a juvenile *O. mykiss* PIT-tagged above Condit Dam September of 2004 at 98 mm was detected ascending Bonneville Dam in July of 2006. Genetic analysis of juvenile *O. mykiss* collected in the upper watershed above Husum Falls are different from hatchery trout released in the basin, however additional samples are needed to confirm this finding (Allen et al. 2006). This information supports the theory that even though the population is functionally extirpated there is still the potential for re-establishing anadromous steelhead in the White Salmon River Basin.

Based on the potential to re-establish natural production of steelhead in the basin, the White Salmon Working Group decided that Option 1, the natural re-colonization approach, was the best suited for the status of *O. mykiss* in the basin. The key to the success of this option is to implement all of the proposed monitoring and evaluation activities, including screw trap operations and the installation of a weir on Rattlesnake Creek to monitor adult escapement, adult movement, and presence/absence of stray hatchery-origin steelhead. In the future, if the need arises, the weir could be used to exclude hatchery-origin adults creating a refuge for naturally produced steelhead. Another reason that the White Salmon Working Group

supported Option 1 was that the removal of Condit Dam provides a rare opportunity to study the natural re-colonization of newly available habitat without using hatchery intervention. Option 1 will be evaluated and an assessment made after 5 years to determine if the approach should continue or if the other proposed options should be considered.

1. Natural re-colonization - no reintroduction efforts from outside sources
    a. Biological Basis.
        i. Potentially a small number of returning native adults but may not be sufficient number to restart population.
        ii. Recent USGS studies identify PIT-tagged resident *O. mykiss* migrating from the White Salmon above Condit Dam. One PIT-tag collected at East Sand Island, and one detected passing back upriver through the Bonneville Dam fishway (steelhead life history may still be present in upper watershed).
    b. O&M Needs
        i. Maintenance of weir(s) in tributary stream(s).
    c. RM&E Needs
        i. Monitor all natural spawner escapements.
        ii. Monitor hatchery stray steelhead on the spawning grounds.
        iii. Juvenile fish surveys for abundance and growth (via PIT-tagging).
        iv. Rotary Screw Trap (both in lower river and above current reservoir site) to collect out migrants for DNA (deoxyribonucleic acid) analysis, and juvenile production.
        v. Adult and juvenile weir trap and/or instream PIT-tag detector for monitoring in Rattlesnake Creek.
        vi. Redd capping to conduct DNA analysis.
2. Wild donor from local watershed as brood source for juvenile release into the White Salmon River. Eggs collected and reared at suitable hatchery, juveniles acclimated and released at White Salmon Ponds.
    a. Biological Basis
        i. Would emphasize collection of wild steelhead from locally adjacent watershed, with similar geomorphologic characteristics and flow regime.
        ii. Marking to minimize harvest and still provide monitoring information on returning adults.
    b. O&M Needs
        i. White Salmon Pond rehabilitation and O&M.
        ii. Juvenile transport at fry or smolt stage.

iii. Possible identification and development of upriver acclimation site.

c. RM&E Needs

i. Monitor natural and hatchery escapement to spawning grounds.

ii. Monitoring natural escapement in brood source river and any impacts to natural population from broodstock collection.

3. White Salmon resident *O. mykiss* as brood source with locally suitable anadromous wild donor stock spawned for juvenile release into upper White Salmon River.

a. Biological Basis

i. Would emphasize both local (resident) and from locally adjacent watershed.

ii. Possible concerns of ESA status of new population.

b. O&M Needs

i. Upper White Salmon release site identified/developed and O&M.

ii. Possible identification and development of upriver acclimation site.

c. RM&E Needs

i. Fish Health monitoring (BKD/IHN concerns).

ii. Assessment of possible effects of use of genetically mixed local donor stock.

4. Develop White Salmon captive brood program using captured outmigrating juveniles.

a. Biological Basis

i. Capture genetically unique White Salmon steelhead for captive brood program development.

b. O&M Needs

i. Transport equipment.

ii. Spawning, incubation, rearing and adult holding facilities.

iii. Possible identification and development of upriver acclimation site.

c. RM&E Needs

i. DNA analysis to ensure White Salmon population.

5. White Salmon Steelhead Kelt Reconditioning. Recondition local spawners to enhance survival to repeat spawning stage.

a. Biological Basis

i. Maximize survival of White Salmon steelhead to bolster early stages of White Salmon re-colonization effort.

b. O&M Needs

i. Adult downstream weir trap to collect females.

ii. Holding area and feed.

iii. Direct stream release locations identified/developed (for release of reconditioned adults).

c. RM&E Needs

i. Monitoring holding/release methods (i.e. release below Bonneville, or release into White Salmon, hold and release into White Salmon just prior to spawning).

ii. PIT-tag adults for Bonneville Dam detection.

iii. Rotary Screw Trap (both in lower river and above current reservoir site) to collect out migrants for DNA analysis.

iv. Acoustic tag monitoring in White Salmon and Columbia plume to track kelt movement.

Appendix II. Current Efforts and Regulations Addressing and Protecting Population Productivity in the White Salmon Watershed

Population Enhancement and Habitat Restoration Actions

Positive change is underway to address limiting factors and threats to improve steelhead habitat conditions. A number of actions are proposed, being planned, or are already being implemented in the watershed to address these conditions and the affected populations.

Recent actions include:

- Planning for population introduction/reintroduction upstream of the former Condit Dam
- Plantings of trees in riparian zones to provide for future shade and LWD recruitment
- Assessment of habitat condition in Rattlesnake Creek to identify opportunities for future restoration actions
- Klickitat County expects to initiate the development of a White Salmon Watershed (WRIA 29b) Management Plan in the near future, pending the availability of funding

Regulatory Protection

Federal, state, county, and tribal regulatory mechanisms are in place to protect habitat from current and future threats posed to listed species through habitat loss and degradation caused by human land uses and development. Numerous voluntary programs are also available to address habitat conservation. In addition, some areas receive special protection through designation, such as Wild and Scenic River reaches, primitive areas, and wildlife refuges.

NOAA Fisheries and/or U.S. Fish and Wildlife Section 7 Consultations

Section 7 of the ESA directs all Federal action agencies to consult with NOAA's NMFS and the USFWS to ensure that all Federal actions/projects will not jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. Actions include not only direct Federal actions, but also actions funded with Federal dollars. A Biological Assessment or Biological Evaluation is usually developed and submitted to NMFS for review prior to implementation of any project. The reader can find additional information regarding the consultation process at: http://www.nwr.noaa.gov/Salmon-Harvest-Hatcheries/Hatcheries/Sec-7-USFWS-Columbia.cfm (accessed April 19, 2012).

Clean Water Act

The Federal Clean Water Act addresses the development and implementation of water quality standards, the development of Total Maximum Daily Loads (TMDL), filling of wetlands, point source permitting, the regulation of stormwater, and other provisions related to protection of U.S. waters. The Clean Water Act is administered in the State of Washington by the WDOE with oversight by the EPA. State water quality standards are set to protect beneficial uses, which include several categories of salmonid use. Ecology has a

water quality certification program under which it reviews projects that will discharge dredged or fill materials into waters of the U.S. and issues certifications that the proposed action meets State water quality standards and other aquatic protection regulations, if appropriate. Ecology also issues National Pollution Discharge Elimination System (NPDES) permits, and develops water quality cleanup plans TMDL to address water quality limited streams.

National Environmental Policy Act (NEPA) Review

NEPA requires Federal agencies to consider the probable impacts of their proposed activities, programs, and projects (including funding of state, local, and private actions) on the quality of the human environment. NEPA reviews help agencies decide whether to undertake a proposed action. In most cases, the NEPA review requires the development of an Environmental Assessment or Environmental Impact Statement (EIS) that addresses the probable effects of a project and its alternatives on various elements of the environment, including soils, geology, landscapes, atmospheric conditions, vegetation, fish and wildlife, and cultural resources. Many Federal funding programs are covered under a general NEPA review completed when the funding program was developed.

Watershed Planning Act

In 1998 chapter 90.82 Revised Code of Washington (RCW) was amended with the passage of Engrossed Substitute House Bill (ESHB) 2514. This law is also known as the Watershed Planning Act. The Watershed Planning Act was established to address the diminishing water availability and quality, and the loss of habitat for fish in the State of Washington. The Watershed Planning Act provides a framework for local citizens, tribes, and state and local agencies to work together to develop and implement Watershed Management Plans for entire watersheds.

As part of the planning process, a watershed assessment is completed for each Water Resource Inventory Area (WRIA) to evaluate water supply and use. Once the watershed assessment is complete, a management plan, followed by a detailed implementation plan, is developed to address water quantity, water quality, and fish habitat issues identified in the assessment. The White Salmon River lies within WRIA 29b. Watershed planning activities are currently on hold due to the state's current budget shortfall.

State Environmental Policy Act (SEPA)

SEPA regulations require an environmental review of actions taken by the state and local agencies, including funding and permitting. Some actions, such as the construction of single-family dwellings, minor road repair, and issuance of business licenses, are exempt. A SEPA review evaluates the probable environmental effects of a proposed project. This information is used to determine if the action should be taken as proposed, if mitigation is necessary, or if the proposal should be rejected.

Forest & Fish Regulations (Washington State)

The Washington Forests & Fish Law, ESHB 2091, was signed into law in 1999 as part of The Washington State Forest Practices Act (Title 76.09 RCW), passed in 1974. The Forests

& Fish Law, based on the Forests & Fish Report, resulted in changes to forest practices rules to protect riparian and aquatic resources on more than eight million acres of private forestland. It is intended to meet the provisions of the Federal Clean Water Act concerning non-point source silvicultural practices. Changes to the law included:

- Updates of the stream typing system in the state to improve mapping of fish-bearing waters
- Increases in buffer widths along fish bearing and non-fish bearing streams,
- Changes in forest practices to protect against landslides
- Mandatory requirements to update the forest road system to hydrologically disconnect roads from streams and minimize sediment delivered to streams
- New regulations on pesticide applications to prevent or avoid drift of chemicals into streams
- Increased protection of wetlands
- Changes in enforcement
- Establishment of a scientifically based adaptive management and monitoring process for evaluating the impact of forest practices on aquatic resources
- Establishment of a process for amending the forest practices rules to incorporate new information as it becomes available
- Establishment of a small landowner office to assist non-industrial landowners

Additional information regarding the Forest Practices rules can be found at: http://www.dnr.wa.gov/BusinessPermits/ForestPractices/Pages/Home.aspx (accessed April 19, 2012).

The Washington Department of Natural Resources, on behalf of the State of Washington, submitted applications to NMFS and the USFWS for incidental take permits under section 10 of the ESA. Issuance of these permits would provide assurances that all forest practices activities in compliance with the state forest practices rules and administrative program will satisfy ESA requirements for aquatic species. The two services released the final HCP (habitat conservation plan), the final EIS, and implementing agreement in a ***Federal Register Notice*** on Jan. 27, 2006. This notice provides an opportunity for the public to review the final documents and the responses to public comments on the draft documents.

Klickitat County Shorelines Master Plan

In 1971 the Washington State Legislature passed the Washington Shoreline Management Act, adopted by public referendum in 1972. The purpose of the Act is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines" by requiring every county and many cities to develop a Shoreline Master Plan to govern development in shoreline area http://www.ecy.wa.gov/programs/sea/sma/st_guide/intro.html (accessed April 19, 2012). Klickitat County's Shorelines Master Plan (SMP) was first adopted in 1975 and has been updated periodically since then. The SMP and brochure on the shorelines permit program can be accessed from the Klickitat County Planning Department's website: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788 (accessed April 19, 2012).

The Klickitat County's SMP regulates "development" within the "shorelines" of the White Salmon River and other water bodies in Klickitat County's jurisdiction. "Development" is broadly defined as: construction or exterior alteration of existing structures; dredging; drilling; dumping; filling; removal of any sand, gravel or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to the SMP regulations at any state of water level. "Shorelines" are those lands extending landward for 200 feet in all directions as measured from the ordinary high water mark, floodways and contiguous floodplain areas landward 200 feet from such floodways; all wetlands and river deltas associated with the streams and lakes. The SMP applies to the shorelines of the mainstem of the White Salmon River as well as the shorelines of all tributaries with a mean annual flow of 20 cfs or more.

The SMP designates various shorelines of the White Salmon River and its tributaries as "environments", which determine the level of protection that is warranted. Much of the White Salmon River is designated either "Natural Environment" which prohibits most development within its shorelines or "Conservancy Environment", which allows a limited scope of development, subject to conditions (i.e., shoreline conditional use permit). Each development proposal is subject to review pursuant to the shoreline environment within which it is to be located. One or more shoreline permits must be secured prior to implementation: Substantial Development Permits are required for any development for which the total cost or fair market value exceeds $5,000, or any development which materially interferes with the normal public use of the water or shorelines; Shoreline Conditional Use Permits (CUP) are required for development types that warrant conditions to ensure consistency with the SMP; and Variances are issued to grant relief from specific bulk, dimensional, or performance standards of the SMP in order to avoid unnecessary hardship, provided that extraordinary circumstances are shown to exist and the public interest shall suffer no substantial detrimental effect. Some types of development, such as a single-family residence, normal maintenance and repair, or construction of a normal protective bulkhead for a single family residence, are exempt from the requirement of a substantial development permit, but are still subject to all other provisions of the SMP.

Existing structures and developments that were established prior to adoption of the SMP are considered legally established "non-conforming" uses. Since adoption of the SMP, the County and WDOE have reviewed all developments within shorelines, including modifications to non-conforming uses, to ensure compliance with the goals and requirements of the SMP.

The WDOE reviews the County's permit decisions and has final authority to approve or deny CUPs and Variances. Persons may appeal the final decision to the Shorelines Hearings Board.

Klickitat County Critical Areas Ordinance

Klickitat County adopted a Critical Areas Ordinance (CAO) in 2001 and, with the concurrence of WDFW, Community Trade and Economic Development, and Ecology, amended it in 2004. The CAO extends beyond the geographical scope of the County's SMP

to protect wetlands, critical fish/wildlife habitat, geologically hazardous areas, aquifer recharge areas, and frequently flooded areas. The CAO is, in effect, an overlay on existing land use regulations. The CAO provides for standard setbacks of 300' from Category I wetlands, 200' from Category II, and 75' from Category III and IV. The CAO provides for standard buffers of 200' from Type 1 & 2 waters; 150' from Type 3 waters; 50' from Type 4 waters; and 25' from Type 5 waters. A wildlife habitat management plan is required for new development that will likely impair salmonid habitat functions and values. As with the SMP, developments and uses that existed prior to the adoption of the CAO are considered legally established "non-conforming" uses. The CAO and brochures land use permit programs can be accessed from the Klickitat County Planning Department's website: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788 (accessed April 19, 2012)

Klickitat County Floodplain Management Ordinance

The Klickitat County Floodplain Management Ordinance (FPO) regulates all development and activities that may increase flood hazards. A permit is required for development within areas of special flood hazard (with at least one percent chance of flooding). The applicant for a non-residential structure must include a certification and flood analysis conducted by a professional engineer. In general, development that does not meet the specific criteria in the ordinance for development in these areas, to protect public health and safety, will be denied. The FPO and brochures land use permit programs can be accessed from the Klickitat County Planning Department's website: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788 (accessed April 19, 2012).

Klickitat County Zoning Ordinance

The Klickitat County Zoning Ordinance (CZO) was adopted in 1979 and has been amended over time. Much of the White Salmon River watershed is zoned by the CZO as "extensive agriculture" which requires a 20-acre minimum lot size for the purpose of dividing properties, and new development/uses are restricted to resource management uses/activities and other compatible uses. One permanent residential dwelling is allowed per lot. Some areas of the watershed are zoned for residential development. The allowable minimum lot size for new lots is either 1 or 2 acres; and one residential dwelling is allowed per lot. Other than residential development, most new development/uses in these zones is either prohibited or allowed per a zoning conditional use permit. The CZO and brochures land use permit programs can be accessed from the Klickitat County Planning Department's website: http://klickitatcounty.org/Planning/default.asp?fCategoryIDSelected=301427788 (accessed April 19, 2012).

Klickitat County Environmental Ordinance (CEO)

The Klickitat County Environmental Ordinance (CEO) was adopted pursuant to the SEPA. The CEO and SEPA require an analysis of probable significant adverse environmental impacts that may result from a proposed development. The CEO and SEPA require a threshold determination for each proposed development that is not exempt. The threshold determination is a determination that a project will or will not have probable significant

adverse environmental impacts. If a project has probable significant adverse impacts, and an EIS is prepared, any proposed development/use that is not specifically exempt in SEPA, chapter 43.21C RCW, or the SEPA rules adopted by the Department of Ecology, Chapter 197-11 Washington Administrative Code, is required to comply with SEPA. Klickitat County provides applicable state agencies and tribes, as well as the public, the opportunity to review threshold determinations and EISs.

Washington State Water Pollution Control Act (Chapter 90.48 RCW)

This act gives Ecology the authority to protect water quality in the state and to promulgate regulations as needed to achieve this goal. The Act makes discharges of pollutants into waters of the state unlawful and has provisions for enforcement of violations, including the authority and process for issuing compliance orders and civil penalties, and for seeking criminal penalties. The Act also provides for permitting processes, cooperation with other entities, water quality monitoring, grants, and numerous other subjects regarding management of water quality issues in the state.

Washington's Statewide Monitoring Program

In 2001, Substitute Senate Bill (SSB) 5637 was signed into law. This act related to monitoring of watershed health and salmon recovery. The Monitoring Oversight Committee developed a comprehensive statewide strategy that addresses the actions identified in SSB 5637. Among other things, the Plan is intended to provide information regarding trends in fish, water, and habitat conditions and assess effectiveness of actions taken to improve watershed health and provide for salmon recovery. The strategy includes documentation of fish population trends in some areas of the state; however, the White Salmon River watershed is not one of the areas included to date in that monitoring effort. The strategy is also monitoring the effectiveness of habitat restoration efforts funded by the state. The monitoring of project effectiveness follows the Monitoring and Evaluation Strategy (Washington SRFB 2003) that was developed in support of the Comprehensive Statewide Strategy. The Monitoring and Evaluation Strategy specified methods to assess a wide range of restoration and protection projects.

On-Site Sewage Systems

Chapter 246-272 of the Washington Administrative Code regulates the onsite disposal of sewage in the state. The law is applicable to septic systems as well as larger on-site systems. The rule addresses location of systems, site evaluations, design, installation, inspection, operation and maintenance, repair, abandonment, and other areas of concern. The rule helps to prevent the discharge of sewage into fish-bearing streams.

Hydraulic Code

Chapter 75.20 RCW governs construction projects within the waters of the State of Washington. The law requires hydraulic project approvals from the WDFW, Department of Fish and Wildlife for wharves, bulkheads, bridges, culverts, fish habitat restoration projects, and other construction activities within the ordinary high water mark. This regulation helps to protect fish and fish habitat during construction.

Regulation of Dairy Farms

Chapter 90.64 RCW, the Dairy Nutrient Management Act, includes a number of requirements designed to protect water quality from dairy operations. These are in addition to NPDES requirements in the Federal and state Clear Water Acts for concentrated animal feeding operations. The Act requires inspection of all dairy farms, implementation of dairy nutrient management plans, technical assistance and enforcement (including civil penalties) against significant polluters. The intent of the regulation is to protect water quality and, subsequently, fish habitat. The WDOE is the primary regulatory authority under this Act.

Other Rules and Regulations

There are over 100 additional rules and regulations applicable to the protection of water quality and fish habitat in the State of Washington. These rules cover a broad range of subjects such as groundwater quality standards, application of pesticides, well construction, motor oil disposal, utilities, solid waste disposal and recycling, water supply facilities, mining, energy facilities, dikes and levees, aquiculture, etcetera. Lists of applicable laws and rules and links to the specific requirements of those laws and rules can be found at: www.ecy.wa.gov/laws-rules.

Yakama Reservation Forest Management Plan

The YN has a variety of protective land use regulations in effect on reservation lands. One of these is the FMP. Under the 1993-2002 FMP, the Yakama Administrative Forest was divided into 11 Land Use Management Areas (LUMA). Each LUMA was managed for multiple uses with emphasis on dominant resource features and objectives. The draft FMP soon to be ratified changes the designation of LUMAs to Management Emphasis Areas (MEA), which will be managed within the forest habitat types (BIA and YN 2004). The forestry program is using historical species composition and stand densities as references for the desired future stand conditions. Just as with the health of aquatic systems, forest health describes the ability of a forest ecosystem to remain productive, to maintain a diversity of plants and animals, aesthetic appeal, and resource sustainability, and to withstand disturbances over time. In addition, a healthy forest is resilient to periodic disturbances such as drought, insects, diseases, fires, climatic change, and management practices.

The FMP prescribes the number of miles and density of roads allowed to be built for the purpose of harvesting timber from the Administrative Forest, and forest treatments such as thinning and prescribed burns are being put into place to move the forest vegetation more toward the historical condition of seral stands rather than dense, late successional forest cover. Streams are classified according to their flow, use for domestic purposes and use by fish for spawning, rearing and migration, and buffers and harvest restrictions are set accordingly. The objectives are the preservation of stream bank and riparian cover, water quality and flow maintenance and soil stabilization (BIA and YN 2004).

Fisheries Management and Evaluation Plan

Recent policy changes will reduce potential harvest impacts. A Fisheries Management and Evaluation Plan (FMEP) for tributary fisheries in the Washington portion of the LCR

Chinook salmon, steelhead, and chum salmon ESUs (WDFW 2002) has been approved by NMFS. WDFW has also requested NMFS approval on a proposed supplement to the FMEP that covers tributary fisheries impacts on listed LCR coho salmon. The agency has also submitted a FMEP for MCR steelhead to NMFS that includes management for recreational fisheries in the White Salmon River. The FMEP minimizes harvest impacts to listed steelhead through the use of selective fisheries that target marked hatchery steelhead and requires the release of all unmarked steelhead. The FMEP also includes management actions that limit impacts to juvenile steelhead through fishing seasons, area closures, and gear restrictions. NMFS is currently reviewing the FMEP to determine if it can be approved under the 4(d) rule limit 4 for MCR steelhead.

Hatchery and Genetic Management Plans

The USFWS submitted HGMPs to NMFS for approval under section 7 of the ESA. NMFS issued a section 7 Biological Opinion on November 27, 2007 for these hatchery programs (http://www.nwr.noaa.gov/Salmon-Harvest-Hatcheries/Hatcheries/Sec-7-USFWS-Columbia.cfm) (accessed April 19, 2012). . Many actions and measures in the HGMPs have already been implemented. These HGMPs cover programs that release fish into the LWS River and at the Spring Creek NFH. WDFW has also submitted an HGMP to NMFS for the releases of summer and winter steelhead into the White Salmon River. These programs may adversely affect listed populations in the White Salmon River and are being evaluated in a Biological Opinion. All of these programs are funded in whole or partially through the Mitchell Act, which is administered by NMFS. An EIS for NMFS' funding of the Mitchell Act and its hatchery programs is being drafted and will include evaluation of the programs listed above.

Special Land Use Areas

Several areas in the White Salmon drainage have received special Federal protection**.**

Columbia River Gorge National Scenic Area

"The National Scenic Area was created to protect and enhance the scenic, natural, cultural and recreational resources of the CR Gorge while encouraging economic development" (www.fs.fed.us/r6/columbia/). The White Salmon River downstream of Condit Dam, RM 3.3-mouth, is within the boundaries of the Gorge National Scenic Area. All new development and land uses must be reviewed in the National Scenic Area to determine if they are consistent with the Act and the implementing land-use ordinances. The development guidelines of the management plan are implemented through land-use ordinances that must be consistent with the management plan.

Wild and Scenic Rivers

The Wild and Scenic Rivers Act was created by Congress to preserve in a free-flowing condition selected rivers of the nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historical, cultural, or other similar values. The nine-mile reach from confluence of Gilmer Creek near BZ

Corner to Buck Creek is a Federal Wild and Scenic River. A twenty-mile stretch of the upper White Salmon and Cascade Creek received Senate approval for Wild and Scenic designation and awaiting presidential approval. The Act restricts the construction of any dam or other water resource project on or directly affecting a designated river or that would have a direct and adverse effect on the values for which such a river was established, such as its free-flowing nature. The Act directed the Forest Service to develop management plans for these portions. The Wild and Scenic Rivers Act on the White Salmon River does not supersede local Shoreline Management Plans.

References

BIA (Bureau of Indian Affairs) and YN (Yakama Nation). 2004. Yakama Nation. Draft 2005-2014 Forest Management Plan.

Washington Salmon Recovery Funding Board. 2003. Monitoring and Evaluation Strategy for Habitat Restoration and Acquisition Projects. Draft. Available at: www.rco.wa.gov/doc_pages/other_pubs.shtml (accessed 13 July 2010).

WDFW 2002. Washington State Department of Fish and Wildlife. Salmonid Stock Inventory http://wdfw.wa.gov/fish/sasi/ (accessed April 19, 2012).

Appendix III. Jewett Creek

Jewett Creek is a small creek located 2 miles to the east of the mouth of the White Salmon River. Geographically, the creek is located within the ICTRT-identified Klickitat independent population spatial distribution boundary, and is, therefore, within the Klickitat River recovery planning area. Jewett Creek is discussed here since it was not considered in the Klickitat Recovery Plan. Any steelhead found in Jewett Creek are most likely hatchery strays or strays from the Klickitat or other independent steelhead populations.

Jewett Creek does not meet the minimum criteria for consideration in the ICTRT's assessment of intrinsic habitat potential (ICTRT 2008) and is not considered a major or minor spawning area for the Klickitat independent population of the MCR Steelhead DPS. The creek does not have sufficient habitat to support a viable population, and the population has not been identified as contributing to the viability of the middle Columbia steelhead DPS (ICTRT 2004).

The lower portion of the creek runs through roughly 100 yards of pipe located under an existing industrial plant. The Bonneville Pool may back up water within the pipe. The creek daylights for approximately 0.9 miles between the railroad and Highway 14, and then passes under the highway. Another 0.8 miles of habitat is available upstream of the Highway. The gradient of the creek becomes impassable at the Gorge bluffs, located at roughly river-mile 0.35.

Local residents have indicated that fish have been seen up to the gorge bluffs. The entire area of stream, which is accessible to anadromous fish, is within the Bingen City limits. No information is available regarding the quality of the 1.7 miles of available habitat; however, monitoring and evaluation actions have been proposed to identify anadromous fish usage and habitat conditions. The ICTRT determined that at least 9.3 miles (15 km) of habitat is necessary to support a viable population of 500 fish (ICTRT 2004).

References

ICTRT (Interior Columbia Technical Recovery Team). 2004. Preliminary Guidelines for Population-level Abundance, Productivity, Spatial Structure, and Diversity Supporting Viable Salmonid Populations: An Update. December 13, 2005. Interior Columbia Technical Recovery Team. Northwest Fisheries Science Center. Seattle, Washington.

ICTRT. 2008. Current status reviews: Interior Columbia basin salmon and steelhead ESUs. Volume III: MCR Steelhead DPS. May 2008 Draft.

Appendix IV. White Salmon River Implementation Schedule: Summary of Actions and Potential Costs to Restore White Salmon River Anadromous Fish Populations and Their Habitat

The following table lists the recovery actions identified by the Washington Gorge Implementation Team to address salmon and steelhead recovery in the White Salmon River watershed. Actions addressing implementation of PacifiCorp's decommissioning plans, restoration of the reaches affected by the former Northwestern Lake and the former Condit Dam, and harvest practices potentially affecting the rate of recovery are priority actions.

Detailed cost breakdown by specific action.

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
	Chinook	Steelhead	Coho	Chum						
Species Reintroductions	x	x	x		Restore populations	Implement reintroduction plan for White Salmon salmonids	White Salmon Working Group	$0		$0
RM&E	x	x	x	x	Baseline Habitat Data Collection	Gather information needed to identify and prioritize habitat actions that will provide the greatest opportunity to contribute to recovery	PacifCorp, White Salmon Working Group	$131,000		$0
	x	x	x	x	Population Monitoring: - Monitor population abundance and productivity - Monitor proportion and origin of hatchery salmon and steelhead on the spawning grounds	Install & maintain large multiplexing PIT-tag detectors in the lower White Salmon mainstem, & in Buck & lower Rattlesnake Creeks. Report findings.	White Salmon Working Group	$176,000		$176,000

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species	Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
		proportion and origin of hatchery salmon and steelhead on the spawning grounds - Assess the resident trout contribution to smolts below Condit Dam; assess change in resident population after steelhead re-colonization/re-introduction					
			Implement population monitoring in the White Salmon River & Rattlesnake Creek.	White Salmon Working Group	$300,000		$300,000
			Install two small stationary in-stream PIT-tag detectors in the lower most portion of Spring Creek.	USGS	$20,000		$20,000
			Pit-Tag 3,000 juvenile salmonid each year above & below Condit Dam to track individual movement & seasonal growth rates.	USGS	$10,000		$10,000

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
						Conduct adult spawning ground surveys and monitor.	WDFW	$351,000		$351,000
						Create and maintain fish counts & biological database.	WDFW	$9,000		$9,000
						Mark adults for mark-recapture population estimates.	WDFW	$72,000		$72,000
						Derive estimates of salmonid population abundance & complete reporting	USGS & WDFW	$400,000		$400,000
					Population Monitoring: Genetic analses	Compare adult & smolt genetic analyses to ongoing adult salmon escapement estimates of WDFW & smolt outmigration estimates of USGS studies in the White Salmon River.	USFWS	$70,000		$70,000
Habitat	x	x	x		Restore channel, stabilize banks, replant banks, and restore habitat in inundated area currently occupied by the reservoir and habitats downstream of	Implement PacifiCorp's Decommissioning Management Plans.	PacifiCorp	$895,000 to 1,100,000+	$895,000 to 1,100,000+	$0

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
					Condit dam impacted by dam removal	Restore channel mainstream above Condit Dam.	YN, WDFW, UCD	$400,000-600,000	$400,000-600,000	$0
						Restore riparian condition.	UCD	$260,000		$260,000
						Dredge mouth of River if needed	ACOE	TBA		TBA
	x	x	x	x	Protect and conserve existing natural ecological processes	Protect existing habitat from future degradation though existing regulatory structure	Federal, state, county, and local governments			$0
						Protect existing habitat from future degradation though land management plans, conservation easements, acquisitions, reclassification of lands as natural areas	UCD, NRCS, Counties, Land Trusts, landowners	$260,000	$10,000	$250,000

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
	x	x	x		Restore vegetation along stream sections that exceed state standards for temperature	Identify stream segments that are excessively warm; within those areas, work with willing landowners to implement actions to increase density of riparian vegetation where sparse; implement programs to protect existing riparian vegetation, reduce sediment inputs to streams.	YN, WDFW, UCD, Mid-Columbia Regional Fishery Enhancement Group (MCRFEG), Klickitat Co.	$260,000		$260,000
		x	x		Restore passage and connectivity's to habitats blocked or impaired by artificial barriers	In cooperation with irrigation district and others, remove or replace barriers inhibiting upstream passage including dikes, culverts and irrigation structures, provide/upgrade screening of irrigation diversions.	YN, USFWS, WDNR, WDOT, Private landowners, USFS, UCD, or others	$700,000		$700,000
						Indian Creek culvert replacement.	UCD, USFWS, YN, Counties	$368,000	$118,000	$250,000
	x	x	x	x	Reduce nutrient inputs	Reduce runoff of nutrients from septic tanks, dairies, agricultural lands, and other sources.	UCD, WDOE, NRCS, landowners, Counties	$1,111,000	$10,000	$450,000

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
	x	x	x		Improve LWD abundance and recruitment	In cooperation with landowners plan, design and install stable wood and other large debris in steambeds and develop approaches to ensuring long-term LWD recruitment.	UCD, MCRFEG, YN, FS, WDFW, landowners	$715,000	$0	$715,000
						In cooperation with landowners develop grazing strategies that promote riparian recovery.	UCD, landowners	$80,000	$0	$80,000
						Eradicate invasive plant species from riparian areas.	County weed control board, USFS, landowners	$120,000	Unknown	$120,000
					Restore channel	With willing landowners, stabilize streambanks, restore natural channel form, reduce sediment inputs as needed from roads	UCD, landowners, MCRFEG, YN, USFWS, USFS, WDNR	80,000-120,000	$0	80,000-120,000
					Reduce anthropogenic effects on stream flow	Quantify anthropogenic effects on stream flow and identify priority actions	Counties	$200,000	$0	$200,000
						With willing landowners, Implement water conservation measures	Counties, UCD, WDOE	$1,500,000	$0	$1,500,000

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
						Improve irrigation conveyance and efficiency	UCD, landowners	$3,500,000	$0	$3,500,000
						Employ BMPs with willing landowners	Counties, WDFW, YN, USFS, landowners, UCD	$400,000	$0	$400,000
						Protect/restore springs with willing landowners	Counties, WDFW, YN, USFS, landowners, UCD, MCRFEG	$450,000	$0	$450,000
						Increase pool habitat	Counties, WDFW, YN, USFS, landowners, MCRFEG	$900,000	$0	$900,000
						With willing landowners restore wetlands	Counties, WDFW, YN, USFS, landowners, UCD, MCRFEG	$600,000	$0	$600,000
						Hydrologically disconnect roads from streams.	Counties, WDFW, YN, USFS, landowners	$1,500,000	$0	$1,500,000

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
						Control road/stream interactions by reducing erosion potential	Counties, WDFW, YN, USFS, landowners	500,000-700,000	$0	500,000-700,000
	x	x	x	x	Public Awareness	Public Awareness regarding restoration projects and importance of wood in streams and riparian areas	UCD, MCRFEG, WDFW, YN, USFWS,	30,000 to 40,000	$0	30,000 to 40,000
Harvest	x	x	x	x	Harvest Management	Manage harvest for low impact fisheries and rapid population growth	PFMC, U.S. v. Oregon Parties	TBD	**$0**	**$0**
	x	x	x	x	Harvest Management	Adjust tributary harvest regulations in areas where harvest significantly impacts salmon and steelhead population growth	WDFW, YN, Co-managers	$50,000	**$0**	$0
Hatcheries	x	x	x	x	Reintroduction - hatchery production	Rehabilitate White Salmon Ponds and update intake screen	Co-managers USFWS	$450,000	**$0**	**$450,000**
Hydrosystem and Mainstem Predation	x	x	x	x	Maintain or improve hydropower operations and facilities at Bonneville Dam to enhance salmon and steelhead survival	Decrease water travel time during smolt outmigration	BPA, ACOE	Costs addressed in Middle-Columbia River roll-up plan		

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
Hydrosystem and Mainstem Predation	x	x	x	x	Maintain or improve hydropower operations and facilities at Bonneville Dam to enhance salmon and steelhead survival	Improve operation of adult passage, maintain high standards of adult fish passage at Bonneville Dam	BPA, ACOE	Costs addressed in Middle-Columbia River roll-up plan		
Hydrosystem and Mainstem Predation	x	x	x	x	Reduce predation on salmonids	Reduce predation by pinnipeds, piscivores, cornorants, and Caspian terns	BPA, ACOE	Costs addressed in Middle-Columbia River roll-up plan		
Jewett Creek										
RM&E		x	x		Baseline data collection	Determine spatial distribution of salmonids in Jewett Creek.	MCFEG, YN, WDFW	$1,000		
RM&E		x	x		Baseline data collection	Complete gathering information on existing salmonid stocks: determine the status, life histories and genetic composition of fish in Jewett Creek	MCFEG, YN, WDFW,	$2,000		
RM&E		x	x		Baseline data collection	Assess fish passage and habitat conditions in lower Jewett Creek	MCFEG, YN, WDFW, landowners,	$5,000		

Recovery Strategies as Prioritized in Recovery Plan	Applicable Species				Action Type	Specific Action(s)	Potential Implementing Entity(s)	Total Estimated Cost ($)	Total Cost Secured	Funds Needed
Habitat		x	x			Restore riparian areas based on habitat assessment	MCFEG, YN, WDFW, landowners,	$75,000		
								$16,781,000	$1,873,000	$13,993,000